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ABSTRACT

Designed to provide students with the basic skills for an occupation in air conditioning and refrigeration, this curriculum guide includes seven major areas, each consisting of one or more units of instruction. These areas and their respective units are titled as follows: Orientation (history and development, and job opportunities), Safety (general safety and specific safety), Tools (hand tools, special tools, and measuring), Tubing and Pipe (tubing, tubing operations, and pipe), Soldering and Welding (soldering and welding equipment, soft soldering, silver brazing, aluminum soldering, oxyacetylene cutting--welding--brazing, and electric welding), Basic Compression Refrigeration (basic mechanical refrigeration, refrigerant system accessories, refrigerants, and evacuation), and Sealed Systems Servicing (pressurizing and leak testing and charging). Each unit within the major areas includes some or all of the following basic components: performance objectives, suggested activities for teacher and students, information sheets (providing content essential for meeting the cognitive objectives of the unit), assignment sheets, job sheets (giving direction to the skill being taught and allowing both student and teacher to check student progress toward the accomplishment of the skill), visual aids, tests, and answers to the tests. Units are planned for more than one lesson or class period. Full-page illustrations and diagrams are presented throughout the guide. (SH)

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AIR CONDITIONING AND REFRIGERATION
BOOK ONE

by
Gary W. Wantiez

Developed by the
Mid-America Vocational Curriculum Consortium, Inc.

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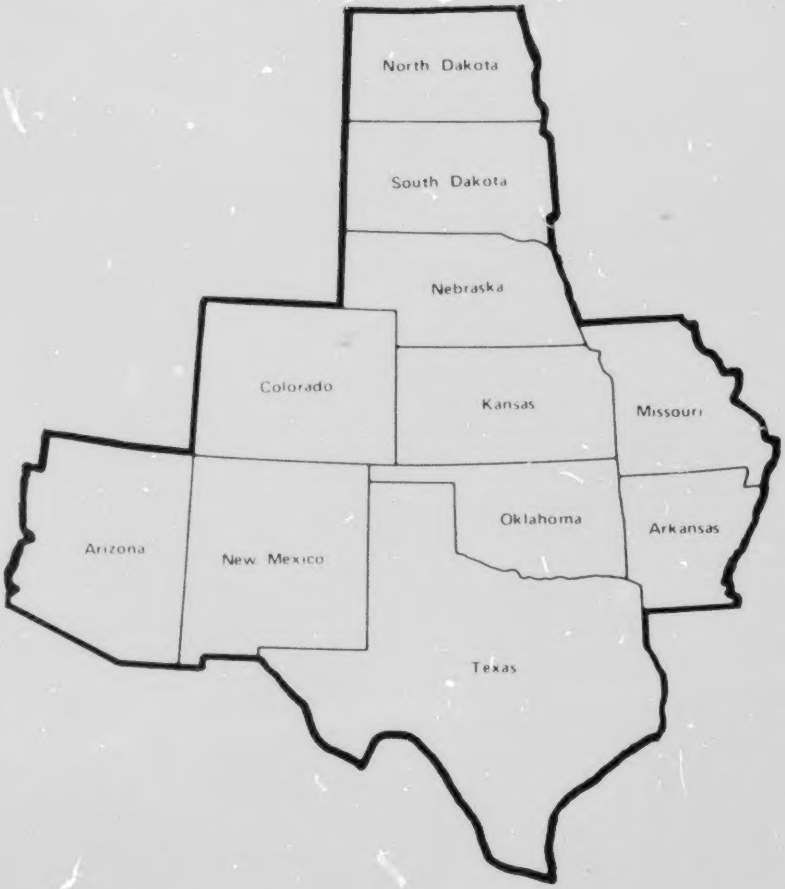
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FOREWORD

The Mid-America Vocational Curriculum Consortium (MAVCC) is an organization which consists of twelve states striving to develop needed instructional materials. As member states, Arizona, New Mexico, Colorado, Louisiana, Missouri, Arkansas, Texas, Oklahoma, Kansas, Nebraska, South Dakota, and North Dakota selected Air Conditioning and Refrigeration as one of the early priorities.

The success of this publication is due, in large part, to the capabilities of the personnel who worked with its development. Gary Wantiez, the technical writer, has numerous years of industry as well as teaching experience. Joining him were representatives of each of the states, all of whom having experiences in education and the trade. And, to be sure all of the materials were technically accurate, many organizations were involved. Special appreciation is extended to the National Environmental Systems Contractors Association (NESCA), Associated Builders and Contractors (ABC), Refrigeration Service Engineers Society (RSES), and The Coleman Company.

This publication is designed to assist teachers in improving instruction. As this publication and the three other volumes are used, it is hoped that student performance will improve and that students will be better able to assume a role in an Air-Conditioning and Refrigeration occupation.

Instructional material in this publication is written in terms of student performance using measureable objectives. This is an innovative approach to teaching that accents and augments the teaching-learning process. Criterion referenced evaluation instruments are provided for a uniform measurement of student progress. In addition to evaluating recall information, teachers are encouraged to evaluate the other areas including process and product as indicated at the end of each instructional unit.

It is our belief that the teaching of this area should become more effective with its use.

Amon Herd, Chairman
Board of Directors
Mid-America Vocational
Curriculum Consortium

PREFACE

The importance of providing every student who is enrolled in an Air-Conditioning and Refrigeration training program with the very best and most complete basic training possible cannot be over emphasized. This first publication of the Air-Conditioning and Refrigeration curriculum was developed with the intent of providing the basic skills and knowledge that the student will need as a good foundation from which to build.

As our nation moves into an era of energy conservation and environmental protection, the demands placed upon the air-conditioning and refrigeration specialist become even greater. Indoor environmental control requires an individual who has a very strong foundation in the basics, in order to obtain maximum efficiency from the climate control equipment with a minimum of energy use.

This publication was developed with the assistance of many individuals very knowledgeable in the trade. Some of these individuals represent professional associations and industry. Their assistance and devotion to this project is greatly appreciated. It should be emphasized that the student needs to be made aware of professional trade associations and take an active part in them as much as possible. The professional trade associations are an excellent avenue for continuing education within the trade. Every student, instructor, and all other individuals associated with this trade should develop the attitude of "professionalism" in their endeavors.

Every effort has been made to make this publication basic, readable, and by all means, usable. Three vital parts of instruction have been intentionally omitted from this publication: motivation, personalization, and localization. These areas are left to the individual instructors and the instructors should capitalize on them. Only then will this publication really become a vital part of the teaching-learning process.

Gary W. Wantiez
Writer

Ann Benson
Executive Director

ACKNOWLEDGMENTS

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The contents of this publication were planned and reviewed by:

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The printing staff of the Oklahoma State Department of Vocational and Technical Education are deserving of much credit for printing this publication.

USE OF THIS PUBLICATION

Instructional Units

The Air Conditioning and Refrigeration, Book I curriculum includes seven areas. Each area consists of one or more units of instruction. Each instructional unit includes some or all of the basic components of a unit of instruction: performance objectives, suggested activities for teacher and students, information sheets, assignment sheets, job sheets, visual aids, tests, and answers to the test. Units are planned for more than one lesson or class period of instruction.

Careful study of each instructional unit by the teacher will help him determine:

A. The amount of material that can be covered in each class period.
B. The skills which must be demonstrated.
    1. Supplies needed
    2. Equipment needed
    3. Amount of practice needed
    4. Amount of class time needed for demonstrations
C. Supplementary materials such as pamphlets and filmstrips that must be ordered.
D. Resource people that must be contacted.

Objectives

Each unit of instruction is based on performance objectives. These objectives state the goals of the course thus providing a sense of direction and accomplishment for the student.

Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction and specific objectives, stating the student performance necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important for the teacher and students to have a common understanding of the intent of the objectives. A limited number of performance terms have been used in the objectives for this curriculum to assist in promoting the effectiveness of the communication among all individuals using the materials.

Following is a list of performance terms and their synonyms which may have been used in this material:

Name
Label
List in writing
List orally
Letter
Record
Repeat
Give

Identify
Select
Mark
Point out
Pick out
Choose
Locate

Describe
Define
Discuss in writing
Discuss orally
Interpret
Tell how
Tell what
Explain

Order
Arrange
Sequence
List in order
Classify
Divide
Isolate
Sort

Distinguish
Discriminate

Construct
Draw
Make
Build
Design
Formulate
Reproduce
Transcribe
Reduce
Increase
Figure

Demonstrate
Show your work
Show procedure
Perform an experiment
Perform the steps
Operate
Remove
Replace
Turn off/on
(Dis) assemble
(Dis) connect

Additional Terms Used
Evaluate
Complete
Analyze
Calculate
Estimate
Plan
Observe
Compare
Determine
Perform

Prepare
Make
Read
Tell
Teach
Converse
Lead
State
Write

Reading of the objectives by the student should be followed by a class discussion to answer any questions concerning performance requirements for each instructional unit.

Teachers should feel free to add objectives which will fit the material to the needs of his students and community. When a teacher adds objectives, he should remember to supply the needed information, assignment and/or job sheets, and criterion tests.

Suggested Activities

Each unit of instruction has a suggested activities sheet outlining steps to follow in accomplishing specific objectives. The activities are listed according to whether they are the responsibility of the instructor or the student.

> Instructor: Duties of the instructor will vary according to the particular unit; however, for best use of the material they should include the following: provide students with objective sheet, information sheet, assignment sheets, and job sheets; preview filmstrips, make transparencies, and arrange for resource materials and people; discuss unit and specific objectives and information sheet; give test. Teachers are encouraged to use any additional instructional activities and teaching methods to aid students in accomplishing the objectives.
>
> Students: Student activities are listed which will help the student to achieve the objectives for the unit.

Information Sheets

Information sheets provide content essential for meeting the cognitive (knowledge) objectives of the unit. The teacher will find that information sheets serve as an excellent guide for presenting the background knowledge necessary to develop the skills specified in the unit objective.

Students should read the information sheets before the information is discussed in class. Students may take additional notes on the information sheets.

Transparency Masters

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheets. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. They should be left on the screen only when topics shown are under discussion.

Job Sheets

Job sheets are an important segment of each unit. The instructor should be able to and in most situations should demonstrate the skills outlined in the job sheets. Procedures outlined in the job sheets give direction to the skill being taught and allow both student and teacher to check student progress toward the accomplishment of the skill. Job sheets provide a ready outline for a student to follow if he has missed a demonstration. Job sheets also furnish potential employers with a picture of the skills being taught and the performances he might reasonably expect from a person who has had this training.

Assignment Sheets

Assignment sheets give direction to study and furnish practice for paper and pencil activities to develop the knowledges which are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided which may be used by the student and/or teacher for checking student progress.

Test and Evaluation

Paper-pencil and performance tests have been constructed to measure student achievement of each objective listed in the unit of instruction. Individual test items may be pulled out and used as a short test to determine student achievement of a particular objective. This kind of testing may be used as a daily quiz and will help the teacher spot difficulties being encountered by students in their efforts to accomplish the terminal objective. Test items for objectives added by the teacher should be constructed and added to the test.

Test Answers

Test answers are provided for each unit. These may be used by the teacher and/or student for checking student achievement of the objectives.

AIR CONDITIONING AND REFRIGERATION
BOOK ONE

INSTRUCTIONAL ANALYSIS

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
SECTION A--UNIT I: HISTORY AND DEVELOPMENT	
	1. Important events in the development of mechanical refrigeration
	2. Important events in the development of air conditioning
UNIT II: JOB OPPORTUNITIES	
	1. Job titles
	2. Demand for workers
SECTION B--UNIT I: GENERAL SAFETY	
	1. Safety color code
	2. Rules for personal safety
	3. Rules for general shop safety
	4. Classes of fires
	5. Types of fire extinguishers
	6. Procedure to follow in case of an accident
7. Demonstrate the procedure for lifting heavy objects	
UNIT II: SPECIFIC SAFETY	
	1. Classification of accidents in the refrigeration shop
	2. Rules for electrical safety

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)

RELATED INFORMATION: What the Worker Should Know (Cognitive)

3. Refrigerant related safety rules
4. Highly flammable gases
5. Safety rules for pressurizing
6. Safety signs and tags

SECTION C--UNIT I: HAND TOOLS

1. Basic hand tools
2. Proper use and care of hand tools
3. Grind a flat tip screwdriver
4. Grind the head of a chisel or punch
5. Sharpen a chisel
6. Cut threads

UNIT II: SPECIAL TOOLS

1. Specialized tools
2. Use and care of specialized tools
3. Sharpen a twist drill bit

UNIT III: MEASURING

1. Measuring instruments
2. Read a rule
3. Use and care of measuring instruments
4. Measure lines
5. Measure diameters
6. Read a circumference rule
7. Use calipers
8. Use a micrometer

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)

SECTION D--UNIT I: TUBING

JOB TRAINING	RELATED INFORMATION
	1. Types of tubing
	2. Applications of tubing
	3. Tubing and refrigerant hose fittings

UNIT II: TUBING OPERATIONS

JOB TRAINING	RELATED INFORMATION
	1. Tubing tools
2. Flare tubing	
3. Make a swage joint	
4. Make a 90° and 180° bend	
5. Make a 45° bend	
6. Construct a tubing project	

UNIT III: PIPE

JOB TRAINING	RELATED INFORMATION
	1. Iron, brass, flexible plastic and p.v.c. pipe fittings
	2. Black pipe and galvanized pipe
	3. Advantages and disadvantages of plastic pipe
	4. Pipe applications
5. Read fitting sizes	
6. Determine lengths of pipe necessary for a given job	

SECTION E--UNIT I: SOLDERING AND WELDING EQUIPMENT

JOB TRAINING	RELATED INFORMATION
	1. Safety rules
	2. Equipment components
	3. Use and care of equipment
4. Light and adjust torches	

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
UNIT II: SOFT SOLDERING	
	1. Types of soft solder and fluxes
	2. Steps in making a solder joint
3. Clean, assemble, and solder a swage joint	
4. Solder an upright, inverted and horizontal joint	
5. Solder with different types of torches	
UNIT III: SILVER BRAZING	
	1. Types of silver brazing alloy and flux
	2. Steps for silver brazing
3. Silver braze various types of joints	
UNIT IV: ALUMINUM SOLDERING	
	1. Torches to be used for aluminum soldering
	2. Procedures for aluminum soldering
3. Aluminum solder	
4. Aluminum braze	
UNIT V: OXYACETYLENE CUTTING, WELDING, AND BRAZING	
	1. Torch parts
	2. Tip sizes
	3. Properties of a weld
	4. Flame characteristics
	5. Purposes of flux

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
6. Set up and adjust equipment	
7. Use cutting and welding equipment	
UNIT VI: ELECTRIC WELDING	
	1. Types of welding machines
	2. Types and sizes of electrodes
	3. Parts of electric welders
	4. Correct lens
	5. Factors determining weld quality
6. Use the electric welder	
SECTION F--UNIT I: BASIC MECHANICAL REFRIGERATION	
	1. Types of compressors, evaporators, condensers, and metering devices
	2. State of refrigerant
3. Assemble a basic refrigeration system	
UNIT II: REFRIGERANT SYSTEM ACCESSORIES	
	1. Refrigerant system accessories
	2. Purpose of refrigerant system accessories
3. Install filter-driers	
4. Use service valves	
UNIT III: REFRIGERANTS	
	1. Common refrigerants
	2. Cylinder color codes
	3. Use of pressure-temperature chart
	4. Methods of leak detection
	5. Safety precautions for refrigerant handling

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
6. Use refrigerant gauges	
7. Use the pressure-temperature chart	

UNIT IV: EVACUATION

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Reasons for evacuating
	2. Effects of air and moisture in a refrigeration system
	3. Types of vacuum pumps and vacuum indicators
4. Evacuate a refrigeration system	

SECTION G--UNIT I: PRESSURIZING AND LEAK TESTING

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Safety rules for pressurizing
	2. Methods of leak testing
	3. Procedure for pressurizing
4. Demonstrate the different methods of leak checking	

UNIT II: CHARGING

JOB TRAINING: What the Worker Should Be Able to Do (Psychomotor)	RELATED INFORMATION: What the Worker Should Know (Cognitive)
	1. Safety rules for handling refrigerants
	2. Advantages and disadvantages of liquid and vapor charging
3. Vapor charge a system	
4. Liquid charge a system	

TOOLS

(NOTE: These are the recommended tools and equipment necessary for an air-conditioning and refrigeration training program.)

Screwdrivers
1. Standard slot
2. Phillips
3. Clutch head
4. Stubby
5. Offset

Wrenches
1. Open end
2. Box end
3. Combination
4. Adjustable open end
5. Pipe
6. Flare nut

Pliers
1. Slip joint
2. Slip groove
3. Long nose
4. Diagonal cutters
5. Plier wrench
6. Pinch-off

Hammers
1. Ball peen
2. Soft face
3. Sledge
4. Claw

Punches, Chisels, and Bars
1. Pin punch
2. Center punch
3. Flat chisel
4. Pry bar
5. Scratch awl

Files
1. Flat
2. Half round
3. Round
4. Point
5. Slim taper
6. Handle

Socket sets
1. Ratchet handle
2. Socket
3. Deep socket
4. Hinge handle
5. Extension
6. Speed handle
7. Universal joint

Tubing tools
1. Flaring tool
2. Tubing reamer
3. Flaring block
4. Cutter
5. Double flare punch
6. Swage punch
7. Lever type bender
8. Bending spring

Accessory hand tools
1. Wire strippers
2. Drop light
3. Oil can
4. Hack saw
5. Screw starter
6. Safety glasses
7. Nut drivers
8. Level
9. Hex-key wrenches

Threading tools
1. Tap
2. Die
3. Die stock
4. T-Handle tap wrench
5. Hand tap wrench

Refrigeration gauge set

Leak detectors
1. Soap solution
2. Halide torch
3. Electronic

Drill motors
1. Straight
2. Offset

Drill bits
1. Twist
2. Wood
3. Masonry

Bench grinders

Vises
1. Bench
2. Pipe

Pullers
1. Wheel
2. Bearing
3. Gear

Thermometers
1. Pocket
2. Remote bulb
3. Flue and stack
4. Thermal electric

Recording thermometers
1. Manual wind
2. Electric

Hygrometers
1. Sling-psychrometers
2. Dial type
3. Humidity recorders

Vacuum pumps
1. Low vacuum
2. Deep vacuum

Vacuum indicators
1. Compound gauge
2. Mercury manometer
3. Thermocouple micron gauge

Capillary tube cleaner
1. Manual type
2. Hydraulic type

Charging cylinders

Service valves
1. Hermetic service valve kit
2. Access valves (core type)
3. Process tube adapters
4. Line piercing valves

Scales

Fin combs

Oil pump

Combustion testing kit

Air meters
1. Aneometer
2. Pitot tube
3. Inclined manometer

Appliance truck

Knock-out cutter

Combination pattern snips

Hand notcher

Hand seamer

Riveter

Riveting hammer

Aviation snips
1. Right hand
2. Left hand

Double cut snips

Hand crimper

Refrigeration ratchet

Air-propane torch
  Torch handle
  Regulator
  High temperature wraparound flame tip
  Standard tips
    1. Small
    2. Medium
    3. Large
  Halide leak detector
  Soldering copper
  Liquified petroleum cylinders
    1. 2 1/2 lb capacity
    2. 20 lb capacity
  Hose--B size with left hand nuts
  Striker

Air-acetylene torch
  Torch handle
  Regulator
  Hose
  Tips
    1. No. 1--Very fine pointed flame
    2. No. 2--Fine
    3. No. 3--Medium
    4. No. 4--Medium large
    5. No. 5--Large
    6. No. 6--Extra large
  High temperature wraparound flame tip
  Halide leak detectors
  Soldering copper
  Acetylene tanks
    11. "B" tank, 40 cubic foot
    2. "MC" tank, 10 cubic foot
  Striker
  Cylinder wrench

Oxyacetylene torch
1. Oxygen regulator
2. Acetylene regulator
3. Torch handle
4. Cutting attachment
5. Welding tip
6. Cutting tip
7. Twin hose
8. Goggles
9. Striker
10. Cart
11. Oxygen cylinder
12. Acetylene cylinder

Electric welder and equipment
1. Electric welder
2. Electrode holder
3. Ground clamp
4. Shield
5. Gloves
6. Chipping hammer
7. Safety goggles
8. Wire brush
9. Electrode

Electrical test instruments
1. Voltmeter
2. Ohmmeter
3. Multimeter
4. Wattmeter
5. Ammeter
6. Millivoltmeter
7. Hermetic analyzer
8. Capacitor analyzer

REFERENCES

(NOTE: This is an alphabetized list of the publications used in completing this manual.)

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HISTORY AND DEVELOPMENT
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to match air-conditioning and refrigeration terms to the correct definitions. The student should also be able to state important developments in air conditioning and in mechanical refrigeration. This knowledge will be evidenced by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with air conditioning and refrigeration to the correct definitions.
2. List the six conditions of conditioned air.
3. State three important events in the development of mechanical refrigeration.
4. State three important events in the development of air conditioning.
5. Distinguish between compression refrigeration components and absorption refrigeration components.

HISTORY AND DEVELOPMENT
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information sheet.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Tour shop and take field trip to a local air-conditioning and refrigeration shop.

  G. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Compression Refrigeration System

    2. TM 2--Absorption Refrigeration System

  D. Test

  E. Answers to test

II. References:

A. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning*. Homewood, Illinois: Goodheart-Willcox Co., 1975.

B. *Refrigeration Service and Contracting.* Vol. 44, No. 2, February, 1976, p. 14-18.

C. Ingels, Margaret. *Father of Air Conditioning.* Garden City, New York: Country Life Press/Doubleday and Co., Inc., 1952.

D. *A to Zero of Refrigeration.* Detroit, Michigan: General Motors, 1961.

HISTORY AND DEVELOPMENT
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Cool--Heat extracted condition of a substance

   B. Heat--Form of energy

   C. Filter--Device that removes unwanted particles from a substance

   D. Humidify--Addition of moisture to the air

   E. Dehumidify--Extraction of moisture from the air

   F. Distribution of air--Method in which certain quantities of air are supplied

   G. Absorption refrigeration--Refrigeration process that occurs when a refrigerant is absorbed by a chemical substance

   H. Compression refrigeration--Refrigeration process that increases the pressure of a refrigerant by mechanical means

II. Conditions of conditioned air

   A. Cooled

   B. Heated

   C. Filtered

   D. Humidified

   E. Dehumidified

   F. Distributed

III. Important events in the development of mechanical refrigeration

   A. 1834--Jacob Perkins patented first refrigeration machine in America

   (NOTE: This machine was a closed compression system and it was not a commercial success.)

   B. 1918--Kelvinator sold first domestic refrigerator to U.S. markets

   C. 1930--Refrigerant #12 was developed

   (NOTE: Refrigerant #12 was one of the first fluorocarbon refrigerants.)

INFORMATION SHEET

IV. Important events in the development of air conditioning

   A. 1908--Carrier Air Conditioning Company was founded

      (NOTE: Willis H. Carrier, a pioneer in refrigerated air conditioning, is referred to as the "father of air conditioning.")

   B. 1934--Frigidaire air-conditioned a complete house

   C. 1935--General Electric installed a heat-pump system

V. Components of refrigeration systems

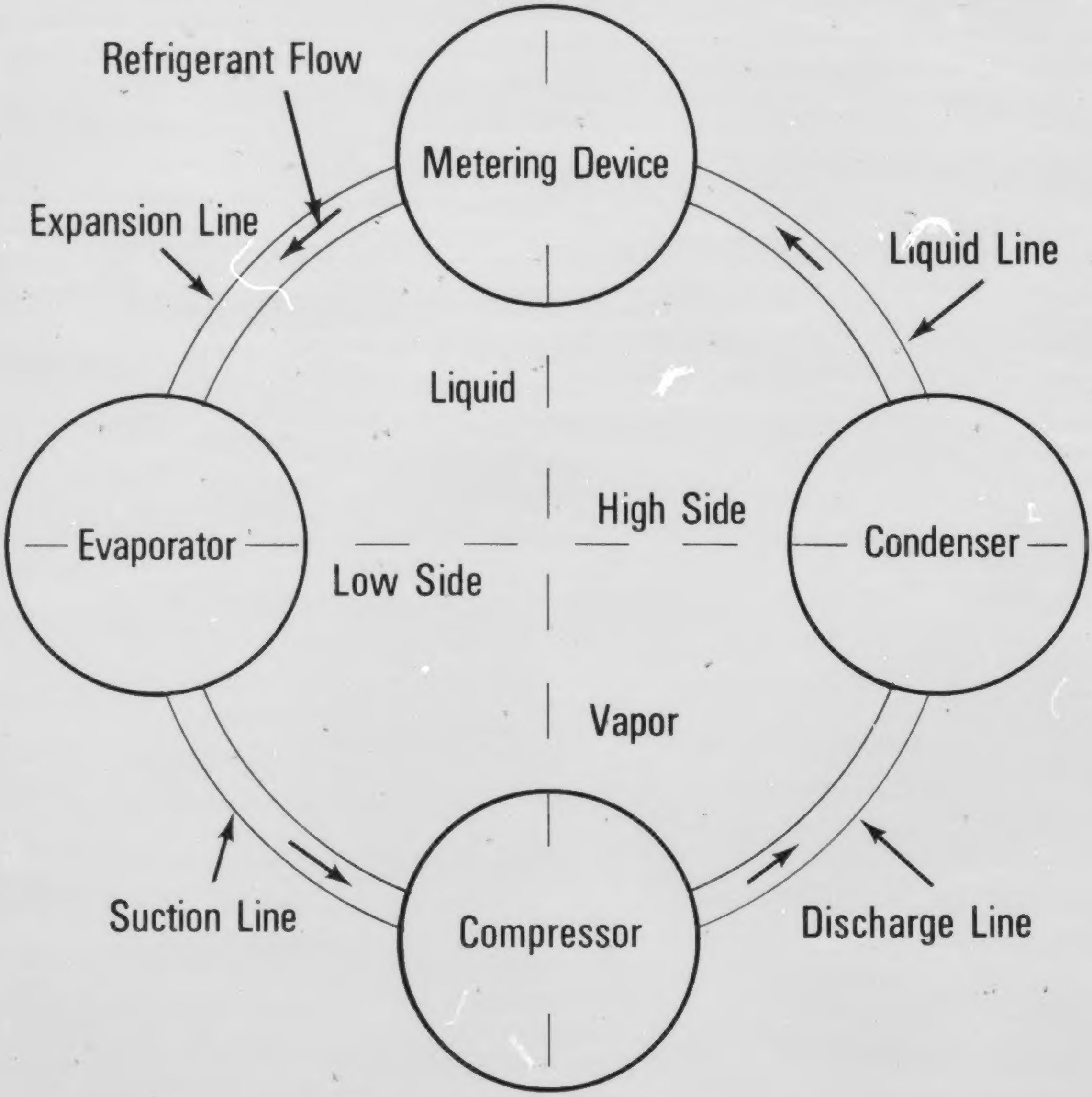
   A. Compression (Transparency 1)

      1. Compressor
      2. Discharge line
      3. Condenser
      4. Liquid line
      5. Metering device
      6. Evaporator
      7. Suction line

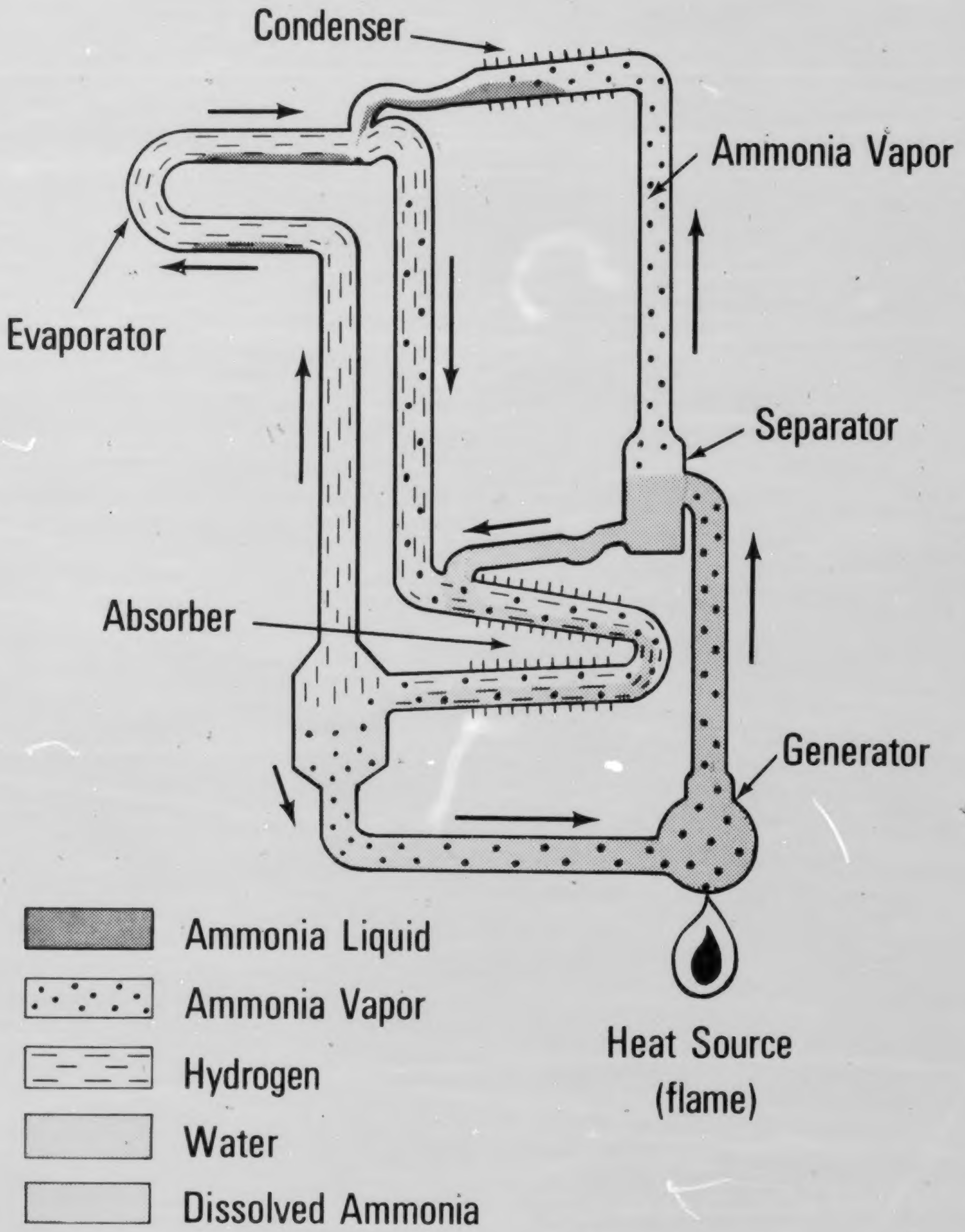
   B. Absorption (Transparency 2)

      1. Heat source (flame)
      2. Generator
      3. Separator
      4. Condenser
      5. Evaporator
      6. Absorber

Compression Refrigeration System


Refrigerant Flow
Metering Device
Expansion Line
Liquid Line
Liquid
Evaporator
High Side
Condenser
Low Side
Vapor
Suction Line
Compressor
Discharge Line

Absorption Refrigeration System


Condenser
Ammonia Vapor
Evaporator
Separator
Absorber
Generator
Heat Source
(flame)
▨ Ammonia Liquid
⁚ Ammonia Vapor
☰ Hydrogen
☐ Water
☐ Dissolved Ammonia

HISTORY AND DEVELOPMENT
UNIT I

TEST

1. Match the terms on the right to the correct definitions.

_____a. Heat extracted condition of a substance

_____b. Extraction of moisture from the air

_____c. Method in which certain quantities of air are supplied

_____d. Refrigeration process that occurs when a refrigerant is absorbed by a chemical substance

_____e. Addition of moisture to the air

_____f. Form of energy

_____g. Device that removes unwanted particles from a substance

_____h. Refrigeration process that increases the pressure of a refrigerant by mechanical means

1. Filter
2. Dehumidify
3. Absorption refrigeration
4. Cool
5. Humidify
6. Heat
7. Compression refrigeration
8. Distribution of air

2. List the six conditions of conditioned air.

a.

b.

c.

d.

e.

f.

3. State three important events in the development of mechanical refrigeration.

a. 1834

b. 1918

c. 1930

4. State three important events in the development of air conditioning.

   a. 1908

   b. 1934

   c. 1935

5. Distinguish between compression refrigeration components and absorption refrigeration components by placing a "C" by the compression components and an "A" by the absorption components.

   ______a. Liquid line

   ______b. Separator

   ______c. Absorber

   ______d. Compressor

   ______e. Heat source (flame)

   ______f. Metering device

   ______g. Suction line

HISTORY AND DEVELOPMENT
UNIT I

ANSWERS TO TEST

1. a. 4
   b. 2
   c. 8
   d. 3
   e. 5
   f. 6
   g. 1
   h. 7

2. a. Cooled
   b. Heated
   c. Filtered
   d. Humidified
   e. Dehumidified
   f. Distributed

3. a. 1834--Jacob Perkins patented first refrigeration machine in America
   b. 1918--Kelvinator sold first domestic refrigerator to U.S. markets
   c. 1930--Refrigerant #12 was developed

4. a. 1908--Carrier Air Conditioning Company was founded
   b. 1934-Frigidaire air-conditioned a complete house
   c. 1935-General Electric installed a heat-pump system

5. a. C
   b. A
   c. A
   d. C
   e. A
   f. C
   g. C

JOB OPPORTUNITIES
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to select job titles within phases of air conditioning and list two job titles for each level of training. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with job opportunities to the correct definitions or descriptions.
2. Select job titles within phases of air conditioning.
3. List two job titles for each level of training.
4. Discuss past and predicted future demands for workers with skills in air conditioning and refrigeration.
5. Select employers of refrigeration or air-conditioning personnel.

JOB OPPORTUNITIES
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:
  A. Provide student with objective sheet.
  B. Provide student with information and assignment sheets.
  C. Discuss unit and specific objectives.
  D. Discuss information and assignment sheets.
  E. Give test.

II. Student:
  A. Read objective sheet.
  B. Study information sheet.
  C. Complete assignment sheet.
  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:
  A. Objective sheet
  B. Information sheet
  C. Assignment Sheet #1--Select Employers of Refrigeration or Air-Conditioning Personnel
  D. Test
  E. Answers to test

II. References:
  A. *Occupational Outlook Handbook.* Washington, D.C.: U.S. Government Printing Office, 1975.
  B. Daly, Donald F. *Your Future in Air Conditioning and Refrigeration.* New York, New York: Arco Publishing Co., 1971.

JOB OPPORTUNITIES
UNIT II

INFORMATION SHEET

I. Terms and definitions or descriptions

A. Air conditioning--Conditioning of the air including cooling, heating, dehumidifying, humidifying, filtering, and distribution

B. Mechanic--Individual that performs a service or installation function

C. Wholesaler--Individual or company that sells equipment, parts, and supplies to retailers

D. Retailer--Individual or company that sells and services equipment to the retail customer

E. Installer--Mechanic that installs the equipment the retailer sells

F. Service man--Mechanic that repairs and maintains the equipment the retailer sells

G. Salesman--Individual that sells the equipment

H. Estimator--Individual that recommends what size and type of equipment the customer needs

(NOTE: In many organizations the salesman is also the estimator.)

I. Manufacturer--Company that makes a particular brand of equipment

(NOTE: This term is generally referred to as O.E.M., which stands for original equipment manufacturer.)

J. Manufacturer's representative--Individual that serves as a liaison between the manufacturer and the retailer

K. Service representative--Individual that is employed by a manufacturer to aid retailers in the proper installation and repair of a particular brand of equipment

II. Job titles

A. Manufacturing

1. Designer
2. Engineer

INFORMATION SHEET

   3. Assembly man
   4. Shipping clerk
   5. Manufacturer's representative
   6. Service representative

  B. Wholesaling
   1. Salesman
   2. Counterman
   3. Shipping clerk

  C. Retailing
   1. Salesman
   2. Estimator
   3. Service manager
   4. Delivery person
   5. Installer
   6. Cooling mechanic
   7. Heating mechanic
   8. Refrigeration mechanic

  D. Building maintenance
   1. Supervisor
   2. Cooling mechanic
   3. Heating mechanic

III. Levels of training

(NOTE: Special licenses may be required in some geographical areas.)

  A. Manufacturing
   1. Designer--Usually requires a four year college program

INFORMATION SHEET

2. Engineer--College degree in mechanical or electrical engineering
3. Assembly man--High school diploma with a mechanical background
4. Shipping clerk--High school diploma with a background in record keeping
5. Manufacturer's representative--High school diploma and some college work with a background in sales
6. Service representative--Technical school training with experience as a cooling, heating, and refrigeration mechanic

B. Wholesaling

1. Salesman--Technical school training with some business training
2. Counterman--Technical school training with bookkeeping experience
3. Shipping clerk--High school diploma with some bookkeeping experience

C. Retailing

1. Salesman--Technical school training with some business training
2. Estimator--Technical school training with emphasis on math and drafting
3. Service manager--Technical school training with extensive experience as a service mechanic
4. Delivery person--High school diploma
5. Installer--Technical school or apprenticeship training and sheet metal, wiring, and piping experience
6. Cooling mechanic--Technical school or apprenticeship training and job experience
7. Heating mechanic--Technical school or apprenticeship training and job experience
8. Refrigeration mechanic--Technical school or apprenticeship training and job experience

INFORMATION SHEET

D. Building maintenance

1. Supervisor--Technical school or apprenticeship training and experience in servicing commercial heating and cooling equipment

2. Cooling mechanic--Technical school or apprenticeship training and experience in servicing commercial cooling equipment

3. Heating mechanic--Technical school or apprenticeship training and experience in servicing commercial heating equipment

IV. Past and predicted future demands

A. Past

1. Estimated 227.000 air conditioning and refrigeration mechanics in 1975

2. Work available in all parts of the country

B. Future

1. Estimated need for 304,000 air-conditioning and refrigeration mechanics by 1980

(NOTE: These figures are based on Air Conditioning and Refrigeration Institute's "Manpower Survey Report", March, 1973.)

2. Increased demand due to

a. Central heating and cooling in more new homes

b. Increase in standard of living

c. Worker promotions, transfers, retirement, and death

JOB OPPORTUNITIES
UNIT II

ASSIGNMENT SHEET #1--SELECT EMPLOYERS OF REFRIGERATION OR AIR-CONDITIONING PERSONNEL

Using the city directory, telephone directory, or area newspapers, list employers of refrigeration or air-conditioning personnel.

1. Manufacturing

2. Wholesaling

ASSIGNMENT SHEET #1

3. Retailing

4. Building maintenance

JOB OPPORTUNITIES
UNIT II

TEST

1. Match the terms on the right to the correct definitions or descriptions.

_____a. Individual or company that sells equipment, parts, and supplies to retailers

_____b. Individual that recommends what size and type of equipment the customer needs

_____c. Mechanic that repairs and maintains the equipment the retailer sells

_____d. Individual that sells the equipment

_____e. Individual that performs a service or installation function

_____f. Conditioning of the air including cooling, heating, dehumidifying, humidifying, filtering, and distribution

_____g. Company that makes a particular brand of equipment

_____h. Mechanic that installs the equipment the retailer sells

_____i. Individual or company that sells and services equipment to the retail customer

_____j. Individual that is employed by a manufacturer to aid retailers in the proper installation and repair of a particular brand of equipment

_____k. Individual that serves as a liaison between the manufacturer and the retailer

1. Mechanic
2. Retailer
3. Estimator
4. Service representative
5. Service man
6. Manufacturer
7. Installer
8. Salesman
9. Air conditioning
10. Wholesaler
11. Manufacturer's representative

2. Select the job titles within the phases of air conditioning by placing an "X" in the appropriate blank.

a. Manufacturing

______1) Delivery person

______2) Designer

______3) Assembly man

______4) Installer

______5) Service representative

______6) Counterman

b. Wholesaling

______1) Engineer

______2) Salesman

______3) Estimator

______4) Shipping clerk

c. Retailing

______1) Salesman

______2) Cooling mechanic

______3) Shipping clerk

______4) Heating mechanic

______5) Refrigeration mechanic

______6) Designer

______7) Assembly man

______8) Estimator

d. Building maintenance

______1) Supervisor

______2) Salesman

______3) Cooling mechanic

3. List two job titles for each level of training.

   a. College

      1)

      2)

   b. Technical

      1)

      2)

   c. High school

      1)

      2)

4. Discuss past and predicted future demands for workers with skills in air conditioning and refrigeration.

5. Select employers of refrigeration or air conditioning personnel.

   (NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

JOB OPPORTUNITIES
UNIT II

ANSWERS TO TEST

1. a. 10
   b. 3
   c. 5
   d. 8
   e. 1
   f. 9
   g. 6
   h. 7
   i. 2
   j. 4
   k. 11

2. a. 2, 3, 5
   b. 2, 4
   c. 1, 2, 4, 5, 8
   d. 1, 3

3. Any two of the following under each level of training.
   a. College
      1) Manufacturing designer
      2) Manufacturing engineer
   b. Technical
      1) Manufacturing service representative
      2) Wholesale salesman
      3) Wholesale counterman
      4) Retail salesman
      5) Retail estimator
      6) Retail service manager
      7) Retail installer
      8) Retail cooling mechanic

   9) Retail heating mechanic
   10) Retail refrigeration mechanic
   11) Building maintenance supervisor
   12) Building maintenance cooling mechanic
   13) Building maintenance heating mechanic

  c. High school
   1) Manufacturing assembly man
   2) Manufacturing shipping clerk
   3) Manufacturer's representative
   4) Wholesale shipping clerk
   5) Retail delivery person

4. Discussion should include:
  a. Past
   1) Estimated 227,000 air-conditioning and refrigeration mechanics in 1975
   2) Work available in all parts of the country
  b. Future
   1) Estimated need for 304,000 air-conditioning and refrigeration mechanics by 1980
   2) Increased demand due to
    a) Central heating and cooling in more new homes
    b) Increase in standard of living
    c) Worker promotions, transfers, retirement, and death

5. Evaluated to the satisfaction of the instructor

GENERAL SAFETY
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to recognize unsafe situations and list rules for shop and personal safety. He should also be able to select the correct fire extinguisher for the classes of fire and match the safety color code with statements of its use. This knowledge will be evidenced through demonstration and by scoring one hundred percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with general safety to the correct definitions.
2. Match the seven colors of the safety color code to the correct applications of their use.
3. List rules for personal safety.
4. List rules for general shop safety.
5. List steps in maintaining a clean and orderly shop.
6. Match the classes of fire to the correct statements defining each class.
7. Label the three components of the fire triangle.
8. Match the type or types of fire extinguishers to the class of fire they are used on.
9. Select steps to be followed in case of an accident in the refrigeration shop.
10. Select the proper steps for lifting heavy objects.
11. Discuss the steps to be followed in case of an accident.

GENERAL SAFETY
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:
  - A. Provide student with objective sheet.
  - B. Provide student with information and assignment sheets.
  - C. Make transparencies.
  - D. Discuss unit and specific objectives.
  - E. Discuss information and assignment sheets.
  - F. Show a safety film if available.
  - G. Invite fire chief to give a talk on fire safety.
  - H. Demonstrate the procedure for lifting a heavy object.
  - I. Give test.

II. Student:
  - A. Read objective sheet.
  - B. Study information sheet.
  - C. Complete assignment sheet.
  - D. Complete activities assigned by instructor.
  - E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:
  - A. Objective sheet
  - B. Information sheet
  - C. Transparency masters
    - 1. TM 1--The Fire Triangle

2. TM 2--Types of Fire Extinguishers

3. TM 3--Lifting

D. Assignment Sheet #1--Discuss the Steps to be Followed in Case of an Accident

E. Answers to assignment sheet

F. Test

G. Answers to test

II. References:

A. *The ABC's of Fire Protection.* Belleville, New Jersey: Kidde Portable Extinguishers/Walter Kidde and Co., Inc.

B. *An Accident Prevention Program for School Shops and Laboratories.* Washington, D.C.: Office of Education/U.S. Department of Health, Education, and Welfare.

C. *Federal Register.* Vol. 36. Number 105. Part II. Department of Labor. May 29, 1971.

D. *Safety Practices and Procedures in School Shops.* Division of Vocational Education/New Jersey Department of Education.

E. *A Look at Service Safety.* Tecumseh, Michigan: Tecumseh Products Co.

III. Additional materials:

A. Film--"Housekeeping Means Safekeeping." 146-009, Journal Films Inc., 930 Pinter Avenue, Evanston, Illinois 60202.

B. Film--"Stop a Fire Before it Starts." 145-024, Journal Films, 909 West Diversey Parkway, Chicago, Illinois 60614.

GENERAL SAFETY
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Safety--State or condition of being safe; freedom from danger, risk, or injury

   B. Accident--Includes any suddenly occurring, unintentional event which causes injury or property damage

   C. First aid--Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

   D. O.S.H.A.--Occupational Safety and Health Act; federal legislation designed to insure safe and sanitary working conditions for employees

II. Colors and application of the safety color code

   A. Federal safety red

      1. Location of fire fighting equipment

      2. Portable containers of flammable liquids

      3. Emergency stop bars, stop buttons, and emergency electrical stop switches on machinery

   B. Federal safety yellow

      1. Caution and for marking physical hazards

      2. Waste containers for explosive or combustible materials

      3. Caution against starting, using, or moving equipment under repair

      4. Identification of the starting point or power source of machinery

   C. Federal safety orange

      1. Dangerous parts of machines

      2. Safety starter buttons and parts of equipment that may cause electrical shock

      3. Exposed parts (edges only) of pulleys, gears, rollers, cutting devices, and power jaws

INFORMATION SHEET

D. Federal safety purple-Radiation hazards

E. Federal safety green

   1. Safety

   2. Location of first aid equipment

      (NOTE: This applies to equipment other than fire fighting equipment.)

F. Federal safety black

   1. Traffic flow

   2. Housekeeping purposes

G. Federal safety white

   1. Traffic flow

   2. Housekeeping purposes

(NOTE: Black and white are used individually or in combination.)

III. Rules for personal safety

A. Wear shop clothing appropriate to the instructional activity being performed

B. Confine long hair before operating rotating equipment

C. Always wear safety glasses; use suitable helmets and goggles for welding

D. Remove ties when working around machine tools or rotating equipment

E. Remove all metal jewelry when working in the shop

F. Conduct yourself in a manner conducive to safe shop practices

G. Use soap and water frequently as a method of preventing skin irritation

IV. Rules for general shop safety

A. Keep all hand tools sharp, clean, and in safe working order

B. Report any defective tools, machines, or other equipment to the instructor

INFORMATION SHEET

C. Retain all guards and safety devices except with the specific authorization of the instructor

D. Operate a hazardous machine only after receiving instruction on how to operate the machine safely

E. Report all accidents to the instructor regardless of nature or severity

F. Turn off the power before leaving a machine tool

G. Make sure all guards and barriers are in place and adjusted properly before starting a machine tool

H. Disconnect the power from machine tools before performing the maintenance task of oiling or cleaning

I. Use a solvent only after determining its properties, what kind of work it has to do, and how to use it

J. Use correct, properly fitting wrenches for nuts, bolts, and objects to be turned or held

K. Keep the shop or laboratory floor clear of scraps and litter

L. Clean up any spilled liquids immediately

M. Store oily shop towels or oily waste in metal containers

N. Clean the chips from a machine with a brush; do not use a towel, bare hands, or compressed air

O. Always wear safety glasses when grinding, buffing, and hammering

P. Do not work overtime in the shop without the instructor being present

Q. Wear safety clothing such as goggles, gloves, shoes, and aprons when welding

R. Consider the safety of others when working in the shop

S. Report any condition that may lead to an accident

T. Watch the bulletin board for safety information and notices

U. Conduct yourself in a safe-like manner at all times

V. Do not throw any object

INFORMATION SHEET

W. Control your temper and don't take chances

X. Use proper tools and equipment for the proper job

Y. Wear gloves when handling material with sharp edges

Z. Operate equipment and machines only when permitted by instructor

AA. Do not distract the attention of a machine operator while working

BB. Make sure everyone is clear when using compressed air to clean

CC. Do only approved work in shop

DD. Check all equipment before turning on switch

EE. Do not work in the dark; use plenty of light

FF. All revolving machine parts should be well guarded

GG. Do not run over extension or drop cords with appliance dolly or air-conditioner cart

HH. All accidents should be recorded in writing

II. All injuries must be given prompt attention

JJ. Do not leave tools on the floor

V. Steps in maintaining a clean and orderly shop

A. Machinery and equipment arranged to permit safe, efficient work practices and ease in cleaning

B. Materials and supplies safely stacked or stored in proper place

C. Tools and accessories safely stored in cabinets, on racks, or other suitable devices

D. Working areas and work benches clear and free of debris and other hazards

E. Floors clean and free from obstructions and slippery substances

F. Aisles, traffic areas, and exits free of materials and other debris

G. Combustible materials properly disposed of or stored in approved containers

INFORMATION SHEET

H. Oily towels stored in approved metal containers

I. Students working in the area instructed on the proper procedures to follow in keeping the area clean and orderly

J. Sufficient brooms, brushes, and other housekeeping equipment readily available

K. Drinking fountain and wash facilities should be kept clean and neat at all times

VI. Classes of fires

A. Class A--Fires that occur in ordinary combustible materials

Example: Wood, rags, and rubbish

B. Class B--Fires that occur with flammable liquids

Example: Gasoline, oil, grease, paints, and thinners

C. Class C--Fires that occur in or near electrical equipment

Example: Motors, switchboards, and electrical wiring

D. Class D--Fires that occur with combustible metals

Example: Magnesium

VII. Components of the fire triangle (Transparency 1)

A. Fuel--Any combustible material

B. Heat--Enough to raise the fuel to its ignition temperature

C. Oxygen--Necessary to sustain combustion

(NOTE: To produce fire these three elements are necessary and must be present at the same time. If any one of the three is missing, a fire cannot be started. With the removal of any one of them, the fire will be extinguished.)

VIII. Types of fire extinguishers and class of fires (Transparency 2)

A. Pressurized water--Operates usually by squeezing a handle or trigger; used on Class A fires

B. Soda acid--Operates by turning extinguisher upside down; used on Class A fires

INFORMATION SHEET

C. Carbon dioxide (CO_2)--Operates usually by squeezing handle or trigger; used on Class B and C fires

D. Dry chemical--Operates usually by squeezing a handle, trigger, or lever; used on Class B, C, and D fires

(NOTE: On Class D fires, dry sand is as effective as any dry chemical other than Purple X. The cost of the Purple X chemical places it out of reach of most shops.)

E. Foam--Operates by turning extinguisher upside down; used on Class A and B fires

IX. Steps to be followed in case of an accident in the refrigeration shop

A. Report all accidents and injuries to the instructor no matter how minor they may seem

B. First aid will be administered if needed

C. Student will be taken to school nurse

D. Student's parent or guardian will be notified if school nurse requires student to see a physician

E. Accident report form will be filled out by instructor

F. Investigation of the accident will take place to determine the cause of the accident and determine ways to prevent the same accident from happening again

X. Steps for lifting heavy objects (Transparency 3)

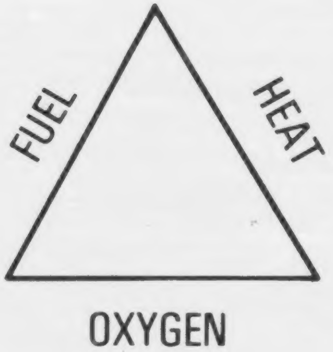
A. Bend knees

B. Keep back straight

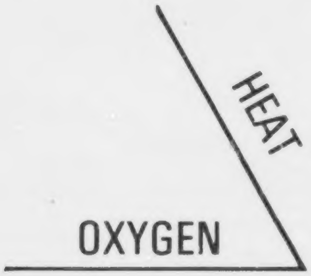
C. Lift gradually with leg muscles

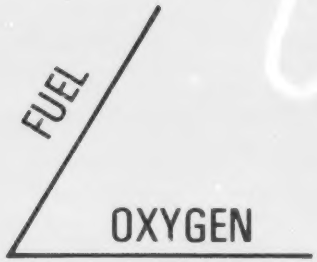
The Fire Triangle

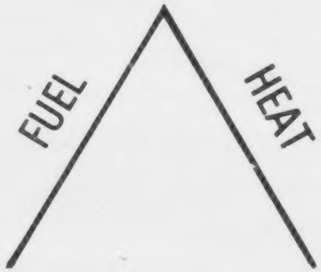
To produce fire, three things must be present at the same time.


FUEL
HEAT
OXYGEN

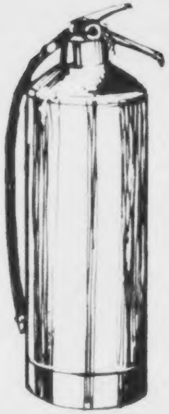
If any one of the three is missing, a fire cannot be started or, with the removal of any one, the fire will be extinguished.


HEAT
OXYGEN

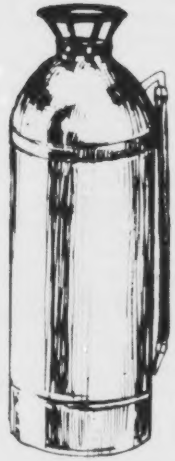

FUEL
OXYGEN



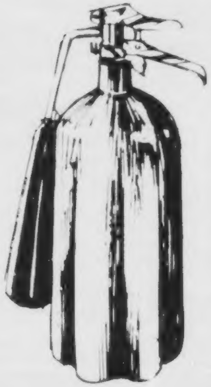
Types of Fire Extinguishers



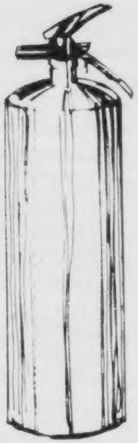
Pressurized Water



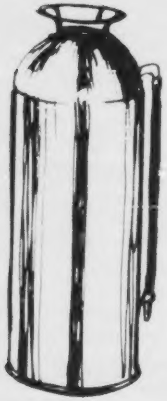
Soda-Acid



Carbon Dioxide

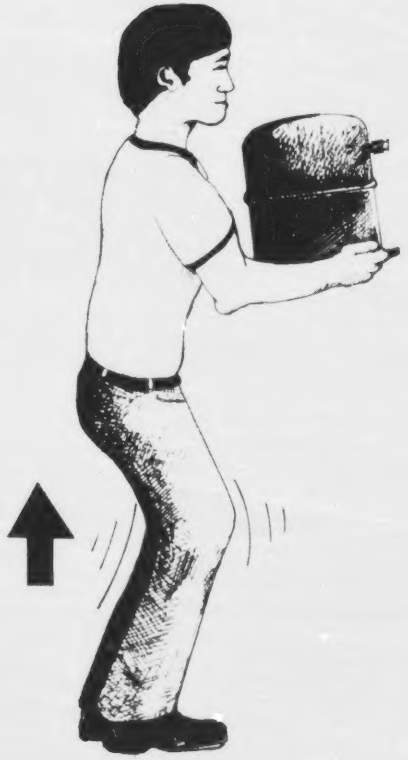


Dry Chemical

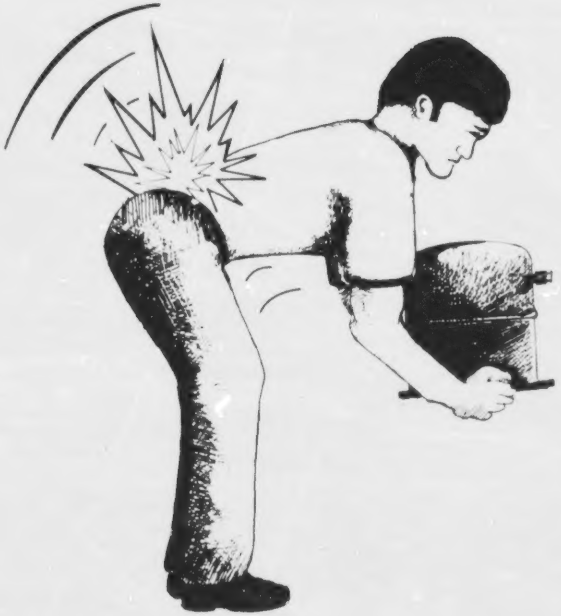


Foam

Lifting



This



Not This

GENERAL SAFETY
UNIT I

ASSIGNMENT SHEET #1--DISCUSS THE STEPS TO BE FOLLOWED IN CASE OF AN ACCIDENT

Given the accident below discuss the steps to be followed, and state the safety rule that would have prevented the accident from occurring.

A student is removing a sheet metal panel and cuts the palm of his hand to the bone.

GENERAL SAFETY
UNIT I

ANSWERS TO ASSIGNMENT SHEET

Discussion should include:

1. Report all accidents and injuries to the instructor no matter how minor they may seem
2. First aid will be administered if needed
3. Student will be taken to school nurse
4. Student's parent or guardian will be notified if school nurse requires student to see a physician
5. Accident report form will be filled out by instructor
6. Investigation of the accident will take place to determine the cause of the accident and determine ways to prevent the same accident from happening again

The safety rule should be stated as follows:

Wear gloves when handling material with sharp edges.

GENERAL SAFETY
UNIT I

TEST

1. Match the terms on the right to the correct definitions.

_____a. Immediate, temporary care given the victim of an accident or sudden illness until the services of a physician can be obtained

_____b. State or condition of being safe; freedom from danger, risk, or injury

_____c. Includes any suddenly occurring, unintentional event which causes injury or property damage

_____d. Occupational Safety and Health Act; federal legislation designed to insure safe and sanitary working conditions for employees

1. Safety
2. Accident
3. First aid
4. O.S.H.A.

2. Match the colors of the safety color code on the right to the correct applications of their use.

_____a. Caution and for marking physical hazards

_____b. Location of fire fighting equipment

_____c. Location of first aid equipment

_____d. Dangerous parts of machines

_____e. Housekeeping purposes

_____f. Traffic flow

_____g. Radiation hazards

1. Federal safety green
2. Federal safety white
3. Federal safety orange
4. Federal safety purple
5. Federal safety black
6. Federal safety red
7. Federal safety yellow

3. List five rules for personal safety.

   a.

   b.

   c.

   d.

   e.

4. List twenty-five rules for general shop safety.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

   i.

   j.

   k.

   l.

   m.

n.

o.

p.

q.

r.

s.

t.

u.

v.

w.

x.

y.

5. List five steps in maintaining a clean and orderly shop.

   a.

   b.

   c.

   d.

   e.

6. Match the classes of fire on the right to the correct statements defining each class.

_____a. Fires that occur with flammable liquids

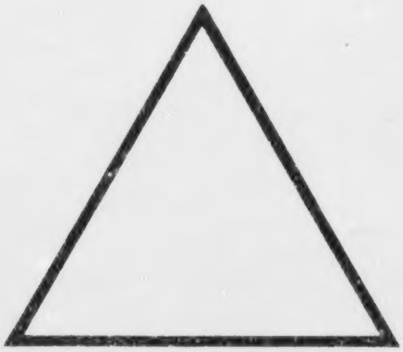
_____b. Fires that occur in ordinary combustible materials

_____c. Fires that occur in or near electrical equipment

_____d. Fires that occur with combustible metals

1. Class A
2. Class B
3. Class C
4. Class D

7. Label the three components of the fire triangle.



8. Match the type or types of fire extinguishers on the right to the class of fire they are used on.

_____a. Class B

_____b. Class C

_____c. Class A

_____d. Class D

1. Pressurized water
2. Carbon dioxide (CO_2)
3. Dry chemical
4. Soda acid
5. Foam

9. Select the steps to be followed in case of an accident in the refrigeration shop by placing an "X" in the appropriate blank.

______a. Investigation of the accident will take place to determine the cause of the accident and determine ways to prevent the same accident from happening again

______b. Apply a tourniquet

______c. Student's parent or guardian will be notified if school nurse requires student to see a physician

______d. First aid will be administered if needed

______e. Mouth to mouth resuscitation will be administered in all cases

______f. Student will be taken to school nurse

______g. Student will be required to sign an insurance release form before he can be attended to

______h. Report all accidents and injuries to the instructor no matter how minor they may seem

______i. First mop up blood to prevent a slick spot on the floor

______j. Accident report form will be filled out by instructor

10. Select the proper steps for lifting heavy objects by placing an "X" in the appropriate blank.

______a. Bend at waist and lift straight up

______b. Keep back straight

______c. Straddle heavy objects before trying to lift

______d. Bend knees

______e. Lift in a quick jerking motion

______f. Lift gradually with leg muscles

11. Discuss the steps to be followed in case of an accident.

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

GENERAL SAFETY
UNIT I

ANSWERS TO TEST

1. a. 3
   b. 1
   c. 2
   d. 4

2. a. 7
   b. 6
   c. 1
   d. 3
   e. 2 and/or 5
   f. 2 and/or 5
   g. 4

3. Any five of the following:
   a. Wear shop clothing appropriate to the instructional activity being performed
   b. Confine long hair before operating rotating equipment
   c. Always wear safety glasses; use suitable helmets and goggles for welding
   d. Remove ties when working around machine tools or rotating equipment
   e. Remove all metal jewelry when working in the shop
   f. Conduct yourself in a manner conducive to safe shop practices
   g. Use soap and water frequently as a method of preventing skin irritation

4. Any twenty-five of the following:
   a. Keep all hand tools sharp, clean, and in safe working order
   b. Report any defective tools, machines, or other equipment to the instructor
   c. Retain all guards and safety devices except with the specific authorization of the instructor
   d. Operate a hazardous machine only after receiving instruction on how to operate the machine safely

e. Report all accidents to the instructor regardless of nature or severity

f. Turn off the power before leaving a machine tool

g. Make sure all guards and barriers are in place and adjusted properly before starting a machine tool

h. Disconnect the power from machine tools before performing the maintenance task of oiling or cleaning

i. Use a solvent only after determining its properties, what kind of work it has to do, and how to use it

j. Use correct, properly fitting wrenches for nuts, bolts, and objects to be turned or held

k. Keep the shop or laboratory floor clear of scraps and litter

l. Clean up any spilled liquids immediately

m. Store oily shop towels or oily waste in metal containers

n. Clean the chips from a machine with a brush; do not use a towel, bare hands, or compressed air

o. Always wear safety glasses when grinding, buffing, and hammering

p. Do not work overtime in the shop without the instructor being present

q. Wear safety clothing such as goggles, gloves, shoes, and aprons when welding

r. Consider the safety of others when working in the shop

s. Report any condition that may lead to an accident

t. Watch the bulletin board for safety information and notices

u. Conduct yourself in a safe-like manner at all times

v. Do not throw any object

w. Control your temper and don't take chances

x. Use proper tools and equipment for the proper job

y. Wear gloves when handling material with sharp edges

z. Operate equipment and machines only when permitted by instructor aa. Do not distract the attention of a machine operator while working

bb. Make sure everyone is clear when using compressed air to clean

cc. Do only approved work in shop

dd. Check all equipment before turning on switch

ee. Do not work in the dark; use plenty of light

ff. All revolving machine parts should be well guarded

gg. Do not run over extension or drop cords with appliance dolly or air-conditioner cart

hh. All accidents should be recorded in writing

ii. All injuries must be given prompt attention

jj. Do not leave tools on the floor

5. Any five of the following:

a. Machinery and equipment arranged to permit safe, efficient work practices and ease in cleaning

b. Materials and supplies safely stacked or stored in proper place

c. Tools and accessories safely stored in cabinets, on racks, or other suitable devices

d. Working areas and work benches clear and free of debris and other hazards

e. Floors clean and free from obstructions and slippery substances

f. Aisles, traffic areas, and exits free of materials and other debris

g. Combustible materials properly disposed of or stored in approved containers

h. Oily towels stored in approved metal containers

i. Students working in the area instructed on the proper procedures to follow in keeping the area clean and orderly

j. Sufficient brooms, brushes, and other housekeeping equipment readily available

k. Drinking fountain and wash facilities should be kept clean and neat at all times

6. a. 2
   b. 1
   c. 3
   d. 4
7. a. Fuel
   b. Heat
   c. Oxygen
8. a. 2, 3, and 5
   b. 2 and 3
   c. 1, 4, and 5
   d. 3
9. a, c, d, f, h, j
10. b, d, f
11. Evaluated to the satisfaction of the instructor

SPECIFIC SAFETY
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to list specific safety rules pertaining to the refrigeration trade. The student should also be able to match ampere figures to their effects on the human body, discuss rescue procedures, and identify color coding on safety signs or tags. This knowledge will be evidenced by scoring one-hundred percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with safety to the correct definitions or descriptions.
2. List the six classifications of accidents in the refrigeration shop.
3. List electrical safety rules.
4. List refrigerant related safety rules.
5. List the seven highly flammable gases used in this trade.
6. List safety rules for using the air-acetylene torch.
7. List safety rules for charging or discharging fluorinated hydrocarbon refrigerants.
8. List safety rules for pressurizing a refrigeration system.
9. List safety rules for handling refrigerant cylinders.
10. List the two major causes of electrical accidents.
11. List six safety rules for using electrical tools.
12. Match ampere figures to their effects on the human body.
13. Discuss rescue procedures in case of electrical accidents.
14. Identify color coding on safety tags or signs.

SPECIFIC SAFETY
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Invite resource people to talk to class.

   Examples: Electric company representative or an air-conditioning contractor

   G. Have students simulate an accident and the proper procedure for handling.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Rescue Procedure

      2. TM 2--"Do Not Start" Tag

    3. TM 3--"Danger" Tag
    4. TM 4--"Caution" Tag
    5. TM 5--"Out of Order" Tag

D. Test

E. Answers to test

II. References:

A. Lieberman, Eli. "Be Aware of Electrical Safety." Refrigeration Service and Contracting, July 1971.

B. Federal Register 37: 22239-22242, October 18, 1972.

C. Downing, R. C. *Refrigerants and Service Pointer Manual.* Wilmington, Delaware: Freon Products Division/E. I. Dupont DeNemours and Co., 1970.

SPECIFIC SAFETY
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Specific safety rules--Safety rules that pertain to a particular trade or operation

   B. Hydrostatic pressure--Pressure created in a vessel by overfilling, which could result in the vessel exploding

   C. Fluorinated hydrocarbons--Group of refrigerants which are nontoxic, nonflammable, nonexplosive, and noncorrosive

   D. Tag--Safety sign that can be affixed to a particular piece of equipment

   E. Ampere--Unit of electrical current flow

   (NOTE: A milliampere would be one thousandth of an ampere. The abbreviation for ampere is amp.)

   F. Toxic--Poisonous

II. Classifications of accidents in the refrigeration shop

   A. Injuries due to mechanical causes

   B. Injuries due to electrical shocks

   C. Injuries due to high pressure

   D. Injuries due to burns and scalds

   E. Injuries due to explosions

   F. Injuries due to breathing toxic gases

III. Electrical safety rules

   A. Do not underestimate the potential danger of a 110 VAC circuit

   B. Be careful around electric arcs because they can cause bad burns to skin and eyes

   C. Remember that the involuntary reaction to electric shock can cause you to injure yourself and possibly others

   D. Work on live circuits only when absolutely necessary

INFORMATION SHEET

E. Refuse to install equipment that will overload a circuit

F. Never bypass an electrical protective device

G. Properly fuse all electrical lines

H. Cover all electrical wires with conduit before running them over refrigerant tubing

I. Properly insulate all electrical wiring

J. Stand on dry nonconductive surfaces when working on live circuits

K. Check all circuits for voltage before doing any service work

L. Tag and lock all electrical disconnects when working on live circuits

IV. Refrigerant related safety rules

A. Ventilate a gas filled room before entering

B. Do not overfill a container because this may cause an explosion

C. Do not pump liquid refrigerant in a compressor because this may cause the compressor to explode

D. Never refill a disposable refrigerant cylinder

E. Never put a flame on a refrigerant cylinder

F. Be careful of acids created in a refrigeration system due to moisture or compressor burnout

G. Never apply a torch to a pressurized system

(NOTE: An exception to this rule is when it is necessary to solder some types of service valves onto the outside of a line while there is pressure in the system.)

H. Do not use refrigerant lines as supports

I. Inspect refrigerant line flares before using

J. Inspect all pressure gauge hoses and connections before using

K. Wear safety glasses when working with refrigerants

L. Never warm a refrigerant cylinder above 125°F

INFORMATION SHEET

- M. Back seat valve stems before removing gauge port caps
- N. Never use carbon tetrachloride as a cleaning solvent because it is extremely toxic
- O. Use naptha with a high flash point of 100°F or more for cleaning
- P. Fluorinated hydrocarbons are nontoxic in moderate amounts unless in the presence of a flame or high temperature surface
- Q. Do not inhale refrigerants
- R. Always remove the door from discarded refrigerators
- S. Never discharge compressed gases toward any person

V. Highly flammable gases used in the trade

- A. Propane
- B. Propylene
- C. Ethane
- D. Ethylene
- E. Methane
- F. Isobutane
- G. Acetylene

VI. Safety rules for using the air-acetylene torch

- A. Always use a regulator
- B. Wear colored safety glasses
- C. Light torch with striker
- D. Open cylinder only one-quarter of a turn
- E. Always set cylinder up against something to prevent it from being accidently knocked over
- F. Do not use a torch on a pressurized system

(NOTE: Air-acetylene torches are commonly referred to as prestolite torches.)

INFORMATION SHEET

VII. Safety rules for charging or discharging fluorinated hydrocarbon refrigerants

A. Be aware that any gas under pressure can be hazardous

B. Do not refill disposable refrigerant cylinders

C. Have adequate ventilation when purging refrigerants

D. Do not discharge fluorinated hydrocarbon refrigerants into an open flame because this will create harmful phosgene gas

E. Never spray liquid refrigerant directly on the skin because this will cause a bad burn

(NOTE: If liquid refrigerant is sprayed directly on the skin or in the eyes, flush the area with cold water and get treatment.)

F. Never apply a torch to a refrigerant cylinder

G. Use a cloth around the hose fittings when removing them from a pressurized system or cylinder

VIII. Safety rules for pressurizing a refrigeration system

A. Never use oxygen or acetylene to pressurize a system

(NOTE: Oxygen will explode on contact with oil. Acetylene will explode under pressure unless dissolved in acetone.)

B. Never use dry nitrogen without a regulator

(NOTE: Nitrogen cylinders contain pressures in excess of 2000 pounds per square inch (p.s.i.)

C. Never apply heat to a pressurized cylinder which could cause a rise in pressure resulting in an explosion

D. Never pressurize refrigerant systems over 150 pounds per square inch gauge (p.s.i.g.) during a leak test

IX. Safety rules for handling refrigerant cylinders

A. Do not drop cylinders

B. Do not refill disposable refrigerant cylinders

C. Do not heat cylinders with a torch

D. Secure cylinders in a moving vehicle

INFORMATION SHEET

- E. Do not spray refrigerant on skin
- F. Do not inhale refrigerant
- G. Do not spray refrigerant into open flame
- H. Do not mix refrigerants
- I. Replace cylinder cap when not in use to protect valve
- J. Do not lift or carry cylinder by valve
- K. Secure large cylinders to wall or bench
- L. Have adequate ventilation
- M. Remove valve or puncture cylinder when discarding disposable refrigerant cylinders

X. Major causes of electrical accidents

- A. Carelessness
- B. Misuse

XI. Safety rules for using electrical tools

- A. Have a ground on all power tools
- B. Use proper size electrical cord
- C. Have proper guards on all tools
- D. Do not use tools with frayed or damaged cords
- E. Stand on dry nonconductive surfaces when using electrical tools
- F. Wear eye protection

XII. Amperes and their effects on the human body

(NOTE: Current is in milliamperes. One ampere is equal to 1,000 milliamperes.)

- A. Less than .5 milliamps--No sensation
- B. 2 to 10 milliamps--Muscular contraction
- C. 5 to 25 milliamps--Painful shock, inability to let go
- D. Over 25 milliamps--Violent muscular contraction

INFORMATION SHEET

E. 50 to 200 milliamps--Heart convulsions, death

F. Over 100 milliamps--Paralysis of breathing, burns

XIII. Rescue procedure in electrical accidents (Transparency 1)

A. Locate live wire and disconnect if possible

B. Decide if it would be easier to move the person or the conductor

(CAUTION: If conductor is to be moved use dry limb or some other nonconductive device; if the individual is to be moved use several thicknesses of paper or cloth as an insulator. Do not take hold of person with your bare hand.)

C. Separate victim and conductor

XIV. Color coding of safety tags or signs

A. "Do not start" tag or sign (Transparency 2)

1. White tag or sign
2. White letters on red square

B. "Danger" tag or sign (Transparency 3)

1. White tag or sign
2. White letters on red oval with a black square

C. "Caution" tag or sign (Transparency 4)

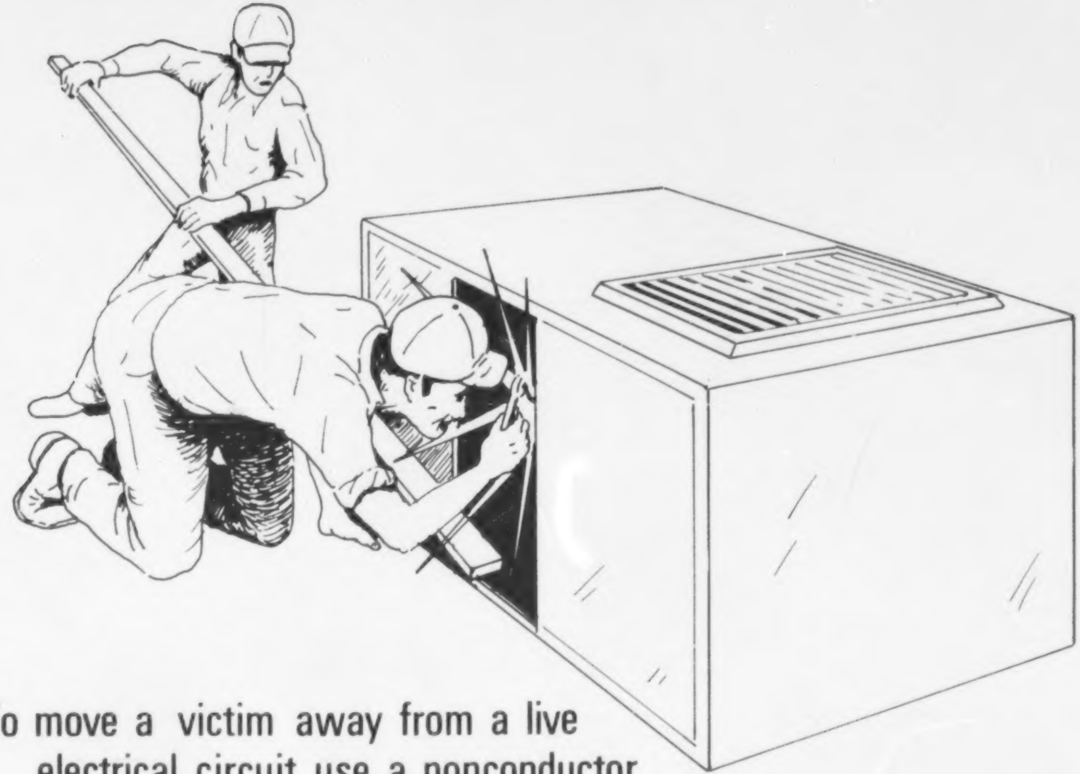
1. Yellow tag or sign
2. Yellow letters on black square

D. "Out of order" tag or sign (Transparency 5)

1. White tag or sign
2. White letters on black square

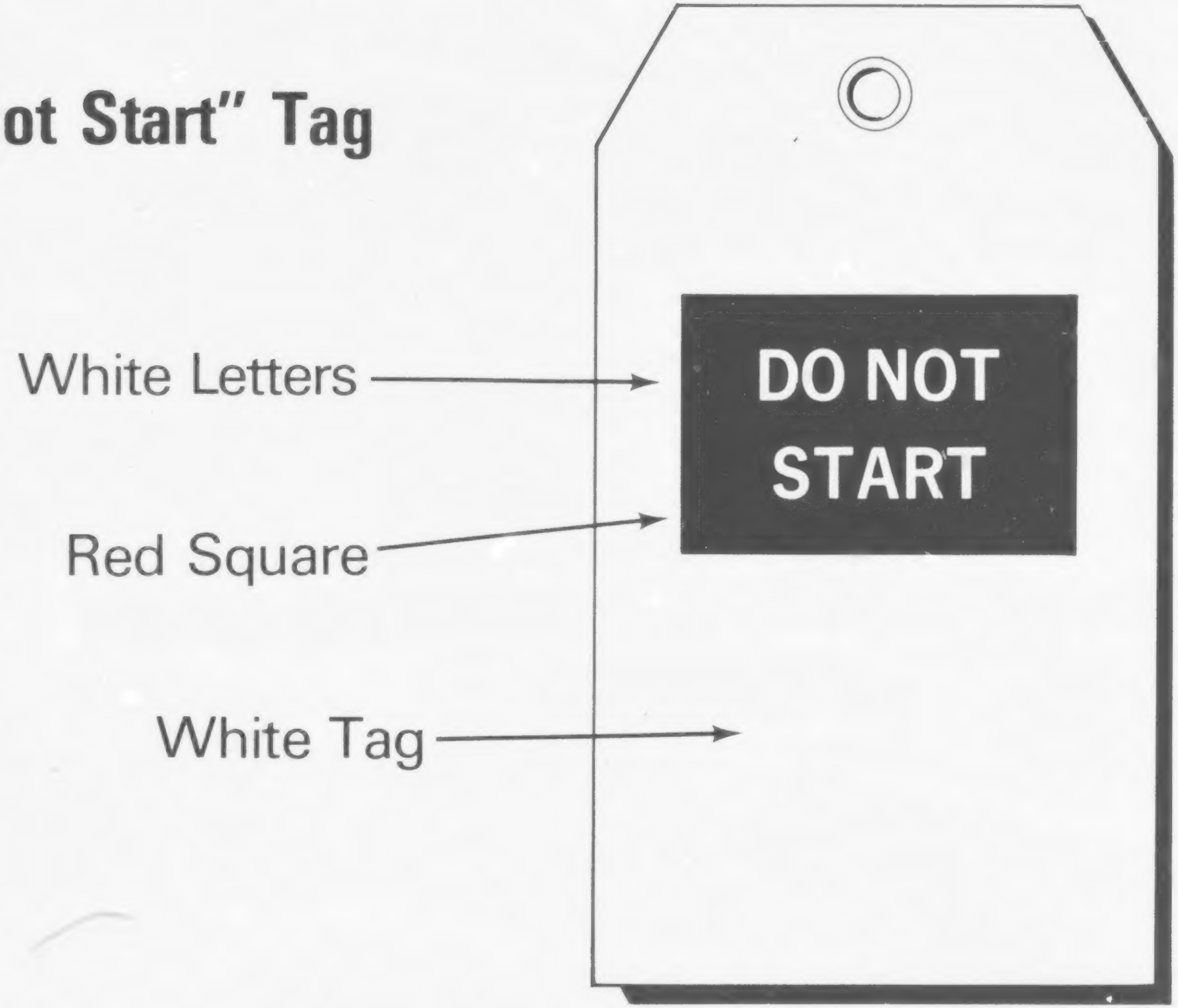
(NOTE: The color coding for a permanent sign is the same as that for a tag.)

Rescue Procedure



To move a victim away from a live electrical circuit use a nonconductor such as a long dry wooden or plastic pole or a very dry tree branch.

"Do Not Start" Tag

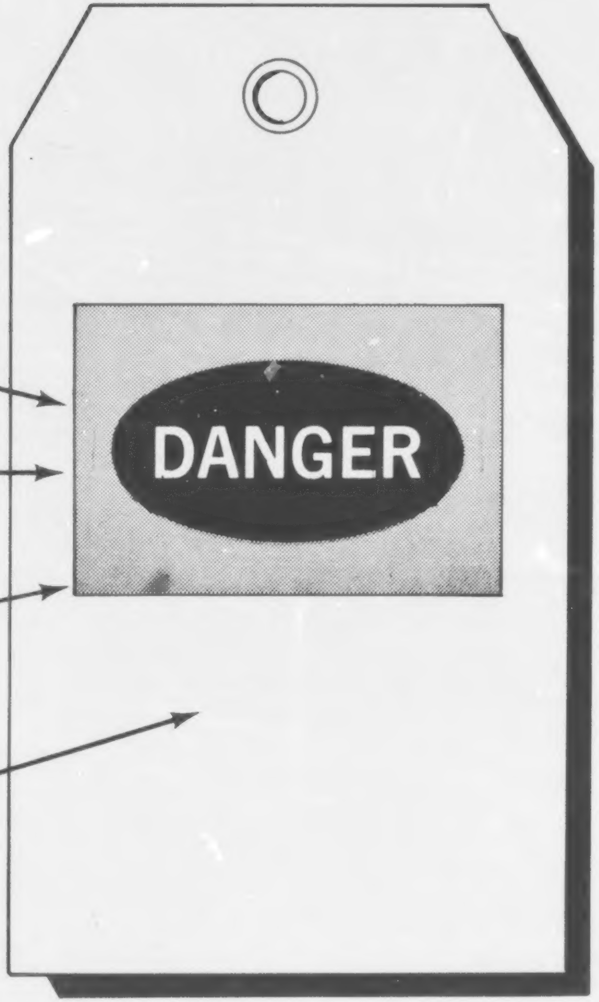

DO NOT
START

White Letters

Red Square

White Tag

"Danger" Tag



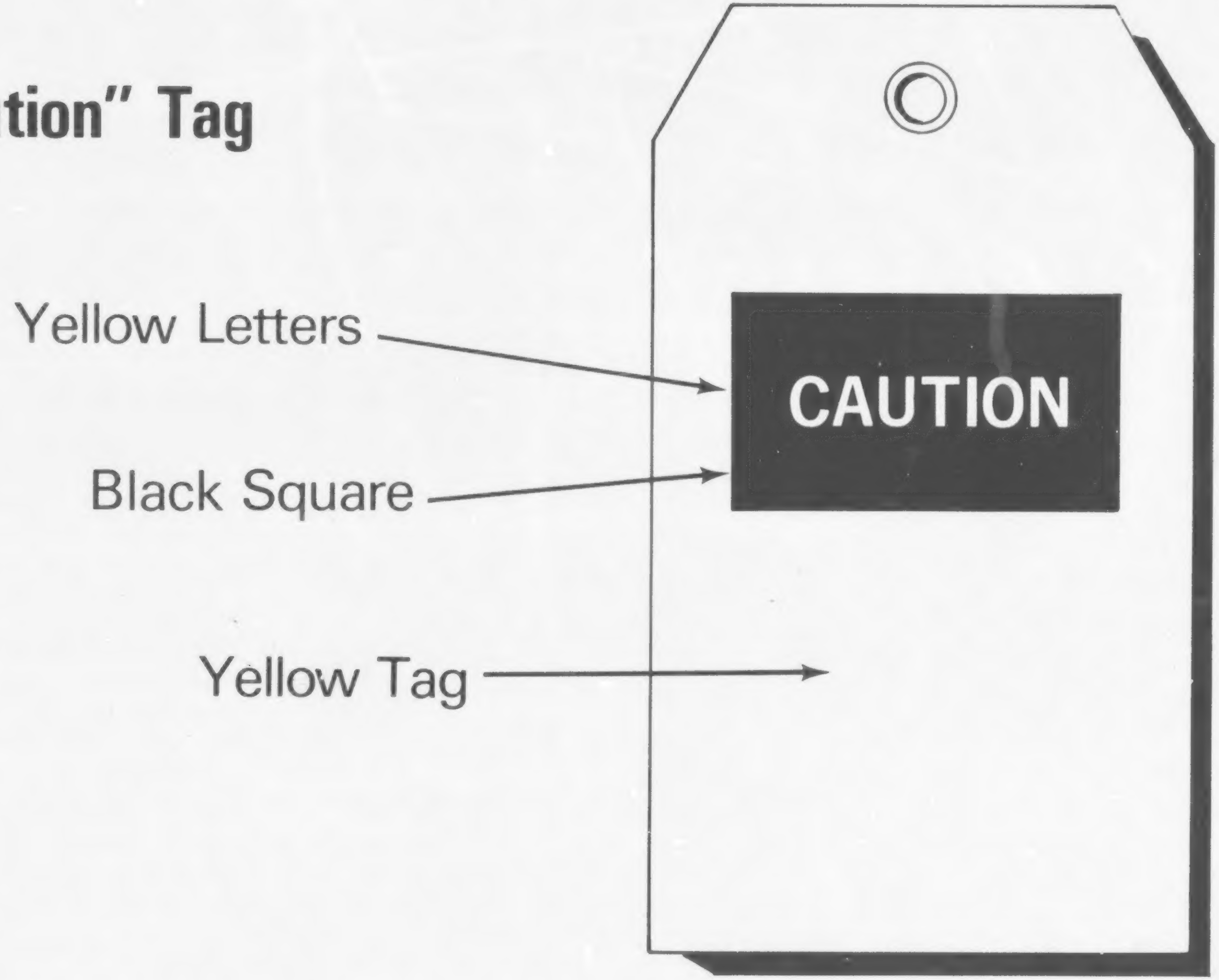
White Letters

Red Oval

Black Square

White Tag

"Caution" Tag

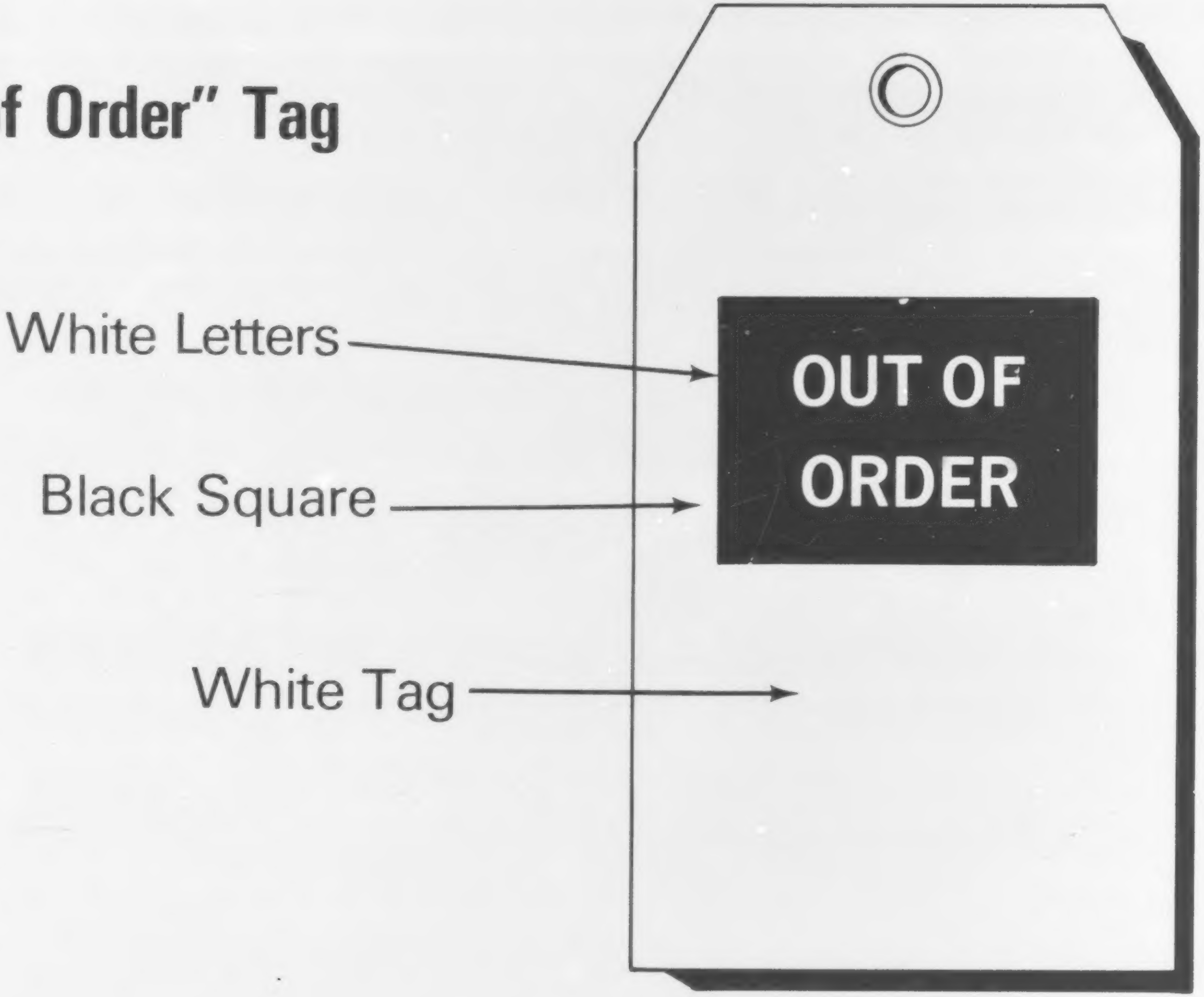


Yellow Letters

Black Square

Yellow Tag

“Out of Order” Tag


White Letters
Black Square
White Tag
OUT OF ORDER

SPECIFIC SAFETY
UNIT II

TEST

1. Match the terms on the right to the correct definitions.

_____a. Unit of electrical current flow

_____b. Group of refrigerants which are nontoxic, nonflammable, nonexplosive, and noncorrosive

_____c. Poisonous

_____d. Pressure created in a vessel by overfilling, which could result in the vessel exploding

_____e. Safety sign that can be affixed to a particular piece of equipment

_____f. Safety rules that pertain to a particular trade or operation

1. Toxic
2. Tag
3. Fluorinated hydrocarbons
4. Specific safety rules
5. Hydrostatic pressure
6. Ampere

2. List the six classifications of accidents in the refrigeration shop.

a.

b.

c.

d.

e.

f.

3. List ten electrical safety rules.

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

4. List ten refrigerant related safety rules.

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

5. List the seven highly flammable gases used in this trade.

a.

b.

c.

d.

e.

f.

g.

6. List four safety rules for using the air-acetylene torch.

   a.

   b.

   c.

   d.

7. List five safety rules for charging or discharging fluorinated hydrocarbon refrigerants.

   a.

   b.

   c.

   d.

   e.

8. List three safety rules for pressurizing a refrigeration system.

   a.

   b.

   c.

9. List eight safety rules for handling refrigerant cylinders.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

10. List the two major causes of electrical accidents.

a.

b.

11. List six safety rules for using electrical tools.

a.

b.

c.

d.

e.

f.

12. Match the ampere figures on the right to their effects on the human body.

______a. Painful shock, inability to let go

______b. Violent muscular contraction

______c. Heart convulsions, death

______d. No sensation

______e. Muscular contraction

______f. Paralysis of breathing, burns

1. Over 25 milliamps
2. 5 to 25 milliamps
3. Over 100 milliamps
4. Less than .5 milliamps
5. 2 to 10 milliamps
6. 50 to 200 milliamps

13. Discuss the rescue procedure in case of electrical accidents.

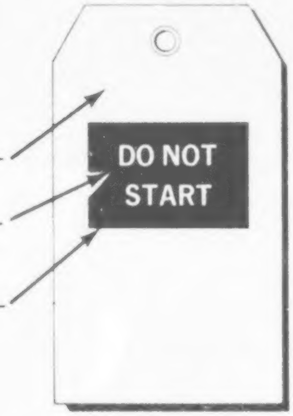
14. Identify color coding on safety tags or signs.

a.

1. ______________

2. ______________

3. ______________


DO NOT
START

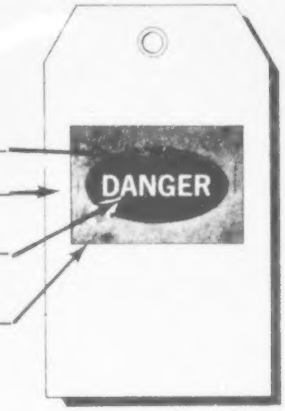
b.

1. ______________

2. ______________

3. ______________

4. ______________

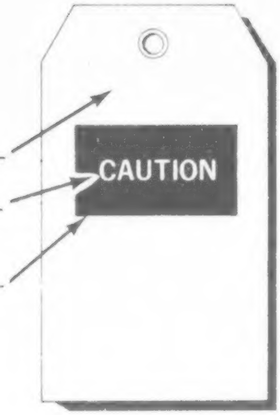


c.

1. ______________

2. ______________

3. ______________

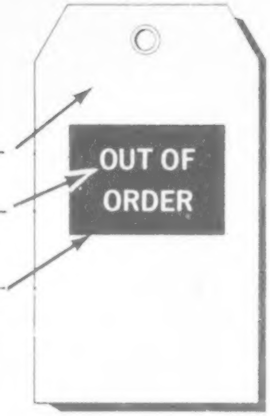


d.

1. ______________

2. ______________

3. ______________


OUT OF
ORDER

SPECIFIC SAFETY
UNIT II

ANSWERS TO TEST

1. a. 6
   b. 3
   c. 1
   d. 5
   e. 2
   f. 4
2. a. Injuries due to mechanical causes
   b. Injuries due to electrical shocks
   c. Injuries due to high pressure
   d. Injuries due to burns and scalds
   e. Injuries due to explosions
   f. Injuries due to breathing toxic gases
3. Any ten of the following:
   a. Do not underestimate the potential danger of a 110 VAC circuit
   b. Be careful around electric arcs because they can cause bad burns to skin and eyes
   c. Remember that the involuntary reaction to electric shock can cause you to injure yourself and possibly others
   d. Work on live circuits only when absolutely necessary
   e. Refuse to install equipment that will overload a circuit
   f. Never bypass an electrical protective device
   g. Properly fuse all electrical lines
   h. Cover all electrical wires with conduit before running them over refrigerant tubing
   i. Properly insulate all electrical wiring

j. Stand on dry nonconductive surfaces when working on live circuits

k. Check all circuits for voltage before doing any service work

l. Tag and lock all electrical disconnects when working on live circuits

4. Any ten of the following:

a. Ventilate a gas filled room before entering

b. Do not overfill a container because this may cause an explosion

c. Do not pump liquid refrigerant in a compressor because this may cause the compressor to explode

d. Never refill a disposable refrigerant cylinder

e. Never put a flame on a refrigerant cylinder

f. Be careful of acids created in a refrigeration system due to moisture or compressor burnout

g. Never apply a torch to a pressurized system

h. Do not use refrigerant lines as supports

i. Inspect refrigerant line flares before using

j. Inspect all pressure gauge hoses and connections before using

k. Wear safety glasses when working with refrigerants

l. Never warm a refrigerant cylinder above 125°F

m. Back seat valve stems before removing gauge port caps

n. Never use carbon tetrachloride as a cleaning solvent because it is extremely toxic

o. Use naptha with a high flash point of 100°F or more for cleaning

p. Fluorinated hydrocarbons are nontoxic in moderate amounts unless in the presence of a flame or high temperature surface

q. Do not inhale refrigerants

r. Always remove the door from discarded refrigerators

s. Never discharge compressed gases toward any person

5.
   a. Propane
   b. Propylene
   c. Ethane
   d. Ethylene
   e. Methane
   f. Isobutane
   g. Acetylene

6. Any four of the following:
   a. Always use a regulator
   b. Wear colored safety glasses
   c. Light torch with striker
   d. Open cylinder only one-quarter of a turn
   e. Always set cylinder up against something to prevent it from being accidently knocked over
   f. Do not use a torch on a pressurized system

7. Any five of the following:
   a. Be aware that any gas under pressure can be hazardous
   b. Do not refill disposable refrigerant cylinders
   c. Have adequate ventilation when purging refrigerants
   d. Do not discharge fluorinated hydrocarbon refrigerants into an open flame because this will create harmful phosgene gas
   e. Never spray liquid refrigerant directly on the skin because this will cause a bad burn
   f. Never apply a torch to a refrigerant cylinder
   g. Use a cloth around the hose fittings when removing them from a pressurized system or cylinder

8. Any three of the following:
   a. Never use oxygen or acetylene to pressurize a system
   b. Never use dry nitrogen without a regulator
   c. Never apply heat to a pressurized cylinder which could cause a rise in pressure resulting in an explosion
   d. Never pressurize refrigerant systems over 150 pounds per square inch gauge (p.s.i.g.) during a leak test
9. Any eight of the following:
   a. Do not drop cylinders
   b. Do not refill disposable refrigerant cylinders
   c. Do not heat cylinders with a torch
   d. Secure cylinders in a moving vehicle
   e. Do not spray refrigerant on skin
   f. Do not inhale refrigerant
   g. Do not spray refrigerant into open flame
   h. Do not mix refrigerants
   i. Replace cylinder cap when not in use to protect valve
   j. Do not lift or carry cylinder by valve
   k. Secure large cylinders to wall or bench
   l. Have adequate ventilation
   m. Remove valve or puncture cylinder when discarding disposable refrigerant cylinders
10. a. Carelessness
    b. Misuse
11. a. Have a ground on all power tools
    b. Use proper size electrical cord
    c. Have proper guards on all tools
    d. Do not use tools with frayed or damaged cords
    e. Stand on dry nonconductive surfaces when using electrical tools
    f. Wear eye protection

12.
- a. 2
- b 1
- c. 6
- d. 4
- e. 5
- f. 3

13. Discussion should include:
- a. Locate live wire and disconnect if possible
- b. Decide if it would be easier to move the person or the conductor
- c. Separate victim and conductor

14.
- a.
  - 1) White tag
  - 2) White letters
  - 3) Red square
- b.
  - 1) Red oval
  - 2) White tag
  - 3) White letters
  - 4) Black square
- c.
  - 1) Yellow tag
  - 2) Yellow letters
  - 3) Black square
- d.
  - 1) White tag
  - 2) White letters
  - 3) Black square

HAND TOOLS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify the basic hand tools used in the trade. The student should also be able to demonstrate the proper use and care of these tools. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with tools to the correct definitions or descriptions.
2. Identify the basic hand tools.
3. Select the appropriate tool from similar groups.
4. Discuss the proper care of hand tools.
5. Demonstrate the ability to:
    a. Grind a flat tip screwdriver.
    b. Grind the head of chisel or punch.
    c. Sharpen a chisel.
    d. Cut external threads.
    e. Cut internal threads.

HAND TOOLS
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Show students actual tools.

   H. Demonstrate use of the grinder.

   I. Demonstrate grinding a bevel.

   J. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Complete activities assigned by instructor.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

C. Transparency masters

1. TM 1--Screwdrivers
2. TM 2--Wrenches
3. TM 3--Pliers
4. TM 4--Hammers
5. TM 5--Punches, Chisels, and Bars
6. TM 6--Files
7. TM 7--Socket Sets
8. TM 8--Tubing Tools
9. TM 9--Accessory Hand Tools
10. TM 10--Threading Tools

D. Job sheets

1. Job Sheet #1--Grind a Flat Tip Screwdriver
2. Job Sheet #2--Grind the Head of Chisel or Punch
3. Job Sheet #3--Sharpen a Chisel
4. Job Sheet #4--Cut External Threads
5. Job Sheet #5--Cut Internal Threads

E. Test

F. Answers to test

II. References

A. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Co., 1975.

B. Krar, S. F.; Oswald, J. W.; and St. Amand, J. E. *Machine Shop Operations.* New York, New York: McGraw-Hill Ryerson Limited, 1975.

HAND TOOLS
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Hand tool--Tool which is hand held and is not electrical or specialized

      (NOTE: The majority of the repair work done in this trade is done with hand tools.)

   B. Specialized tool--Tool designed for a particular use

   C. Screwdriver--Tool designed for tightening or loosening a screw or bolt with a recess opening in the head

   D. Wrench--Tool designed to tighten or loosen a hex head bolt or nut

      (NOTE: Pipe wrenches are in this group and they will fit shaped surfaces other than hex.)

   E. Pliers--Tool with adjustable jaws used for gripping

   F. Hammer--Tool designed to drive, pound, flatten, or shape an object

   G. Files--Cutting tools consisting of various sizes and shapes which are pushed across a piece of metal to bring it to the proper dimension

      (NOTE: Single cut files are sometimes referred to as mill files. Single cut and double cut files are both divided into three grades of coarseness referred to as bastard, second cut, and smooth.)

   H. Swage--Enlarging of one end of a tube so that the end of another tube of the same size will fit into it

   I. National Fine--Type of thread used for precision work

   J. National Coarse--Type of thread used for general purpose work

II. Basic hand tools

   A. Screwdrivers (Transparency 1)

      1. Standard slot

      2. Phillips

INFORMATION SHEET

3. Clutch head
4. Stubby
5. Offset

B. Wrenches (Transparency 2)

1. Open end
2. Box end
3. Combination
4. Adjustable open end
5. Pipe
6. Flare nut

C. Pliers (Transparency 3)

1. Slip joint
2. Slip groove
3. Long nose
4. Diagonal cutters
5. Plier wrench
6. Pinch-off

D. Hammers (Transparency 4)

1. Ball peen
2. Soft face
3. Sledge
4. Claw

E. Punches, Chisels, and Bars (Transparency 5)

1. Pin punch
2. Center punch

INFORMATION SHEET

  3. Flat chisel
  4. Pry bar
  5. Scratch awl

F. Files (Transparency 6)

  1. Flat
  2. Half round
  3. Round
  4. Point
  5. Slim taper
  6. Handle

G. Socket sets (Transparency 7)

  1. Ratchet handle
  2. Socket
  3. Deep socket
  4. Hinge handle
  5. Extension
  6. Speed handle
  7. Universal joint

H. Tubing tools (Transparency 8)

  1. Flaring tool
  2. Tubing reamer
  3. Flare block
  4. Cutter
  5. Double flare punch

INFORMATION SHEET

        6. Swage punch
        7. Lever type bender
        8. Bending spring

    I. Accessory hand tools (Transparency 9)

        1. Wire strippers
        2. Drop light
        3. Oil can
        4. Hack saw
        5. Screw starter
        6. Safety glasses
        7. Nut drivers
        8. Level
        9. Hex key wrenches

    J. Threading tools (Transparency 10)

        1. Tap
        2. Die
        3. Die stock
        4. T-Handle tap wrench
        5. Hand tap wrench

III. Hand tool use

    A. Screwdrivers

        1. Standard slot--For tightening or loosening bolts and screws with a slot type head
        2. Phillips--For tightening or loosening bolts and screws with a phillips type head

        (NOTE: Use proper size to prevent rounding out screw slots.)

INFORMATION SHEET

3. Clutch head--For tightening or loosening a clutch head bolt or screw

   (NOTE: The blade must fit the screw slot in order to function properly.)

4. Stubby--For working in close places where a longer blade would not fit

5. Offset--For working in extremely close places

B. Wrenches

1. Open end--For tightening or loosening hex head bolts, nuts, or screws

2. Box end--For tightening or loosening hex head bolts, nuts, or screws, but is less likely to slip off

3. Combination--For tightening or loosening hex head bolts, nuts, or screws

   (NOTE: This wrench has both an open end and a box end and it enables you to carry a fewer number of wrenches.)

4. Adjustable open end--For tightening or loosening various sizes of hex and square head nuts, bolts, and screws

5. Pipe--Primarily for tightening or loosening round pipe or other rounded surfaces

   (NOTE: This wrench will adjust to fit various size surfaces and it also has teeth to prevent slipping.)

6. Flare nut--For tightening or loosening a flare nut; it has a box end with a notch cut out so that it can be slipped over the tubing

C. Pliers

1. Slip joint--For holding or turning a part where marring of the surface is not a problem

   (NOTE: Pliers should never be used in place of a wrench.)

2. Slip groove--For the same purpose as slip joint but the jaws will generally open wider and the handles provide more leverage

INFORMATION SHEET

3. Long nose--For holding or reaching small items

   Example: Holding a wire terminal while soldering a piece of wire onto it

4. Diagonal cutters--For cutting wire

   (NOTE: These should not be used for tin snips.)

5. Plier wrench--For an excessively tight grip; it has a locking lever to prevent slipping

   (NOTE: These are commonly referred to as vice-grips.)

6. Pinch-off--For crimping refrigeration tubing to prevent the loss of refrigerant while it is being soldered or brazed

D. Hammers

1. Ball peen--For hammering on metal tools such as punches and chisels

2. Soft face--For hammering on or driving materials that a steel face hammer would mar or break

   (NOTE: Soft face hammer faces are made of plastic, rubber, rawhide, copper, lead, or wood.)

3. Sledge--For breaking and pounding; it is heavy, long handled, and has a steel face

4. Claw--Generally for driving and pulling nails

E. Punches, Chisels, and Bars

1. Pin punch--For driving both straight and tapered pins in or out of hubs and shafts

2. Center punch--For making indentations in metal for starting a drill

3. Flat chisel--For cutting off bolt heads or splitting nuts

   (NOTE: A flat chisel is sometimes referred to as a cold chisel.)

INFORMATION SHEET

4. Pry bar--Generally for jobs that require prying an object into alignment

5. Scratch awl--Generally for scratching a line on metal, making screw holes in sheet metal, and for aligning screw holes

F. Files

1. Flat--For smoothing metal surfaces; it is a double cut file

2. Half round--For filing rounded surfaces on metals

3. Round--Generally for enlarging holes in metal

   (NOTE: Round files taper to a point and are sometimes referred to as "rat tail" files.)

4. Point--For filing contact points; it is a small, thin file

5. Slim taper--Generally for cleaning up damaged threads

   (NOTE: Slim taper files are sometimes called saw files.)

6. File handle--Wooden handle placed on the end of the file to prevent it from gouging one's hand

G. Socket sets

1. Ratchet--Permits tightening or loosening with very little swinging room; it is a drive handle that sockets fit onto

2. Socket--For tightening or loosening a hex head bolt or nut; used in conjunction with a drive handle

3. Deep socket--Socket with an extended wall for reaching recessed bolts and nuts or nuts that have the bolt extending through them so far that the standard socket will not fit over them

4. Hinge handle--Drive handle that is used with sockets when more force is needed to break loose or tighten a nut or bolt

   (NOTE: These handles are sometimes called break overs.)

5. Extension--Rod that fits between the socket and the drive handle to extend the socket into hard to reach places

INFORMATION SHEET

6. Speed handle--Drive handle used with a socket to tighten or loosen bolts and nuts quickly that are easy to reach

7. Universal joint--Fits between the drive handle and the socket and bends in any direction enabling the socket to get to hard to reach nuts or bolts

H. Tubing tools

1. Flaring tool--For forcing a 45° cone into the end of a piece of tubing being held by a flaring block which creates a flare on the tubing

2. Tubing reamer--For removing the burr from the inside of tubing after it has been cut

   (NOTE: This is usually attached to the tubing cutter.)

3. Flare block--For holding the tubing while it is being flared or swaged

4. Tubing cutter--For cutting the tubing by tightening it onto the tubing and rotating it at the same time

   (NOTE: These come in large, medium, and small sizes.)

5. Double flare--Device which is placed in the tubing and forced down, which causes the end of the tubing to roll-in, which makes a flare with double tubing thickness

6. Swage punch--Driven into the end of a tube to enlarge it so that another tube of the same size may be placed in it and soldered

7. Lever-type bender--Tubing is held securely against the bender and the arm is slid over the tubing forcing the tubing into the rounded end of the bender

8. Bending spring--Coil spring which is placed on the outside of tubing to keep it from collapsing while bending

I. Accessory hand tools

1. Wire strippers--Removes the insulation from electrical wire without damaging the wire

2. Drop light--For light in dark work areas; it has a protective reflective shield and an electrical outlet in the handle

   (NOTE: These lights usually have 25 ft. or longer cord and should not be used as power cords for high amperage appliances, such as refrigerators, because they are made of small gauge wire.)

INFORMATION SHEET

3. Oil can--Should have a flexible spout for reaching difficult places and a cap to prevent spillage

4. Hack saw--For cutting metals in installation and service work

   (CAUTION: A hack saw is not recommended for cutting refrigeration tubing because the filings will contaminate the system.)

5. Screw starter--For starting small slot or phillips head screws in hard to reach places

   (CAUTION: These are not to be used for tightening or loosening screws.)

6. Safety glasses--Eye protection that should be worn on all jobs

7. Nut drivers--Hollow shaft screwdriver with a permanently attached socket for tightening or loosening hex head bolts and nuts

8. Level--For checking the levelness of air-conditioning and refrigeration units

   (NOTE: Two kinds of levels are the small bubble level and the torpedo level.)

9. Hex key wrenches--For loosening or tightening socket type set screws

J. Threading tools

   1. Taps--For cutting threads inside of hole

      (NOTE: These are available in all types and sizes of threads.)

   2. Dies--For cutting external threads on round stock

      (NOTE: These are available in all types and sizes of threads.)

   3. Handles--For holding taps and dies during the threading process

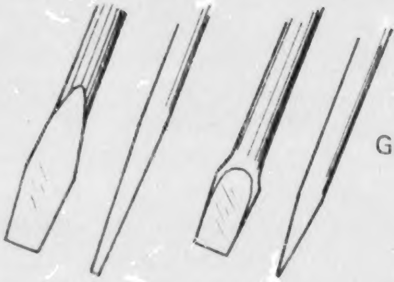
      (NOTE: These include T-handles and hand tap wrenches that hold taps and die stocks for holding dies.)

INFORMATION SHEET

IV. Hand tool care

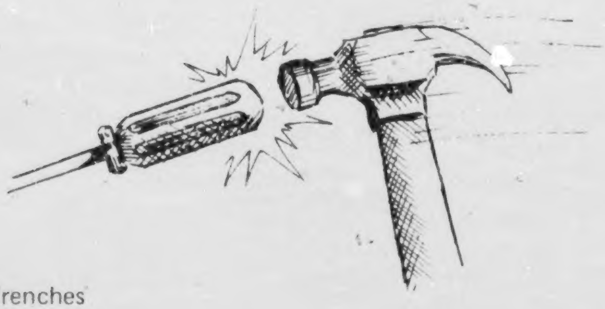
A. Screwdrivers

1. Grind flat tip square


Ground Right
Ground Wrong

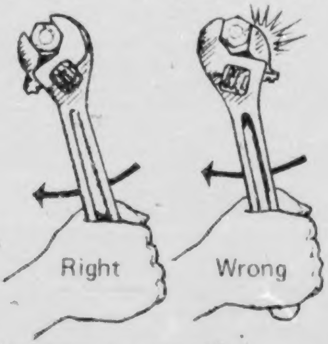
2. Discard worn phillips tips

3. Do not hammer on screwdrivers



B. Wrenches

1. Turn adjustables in proper direction


Right
Wrong

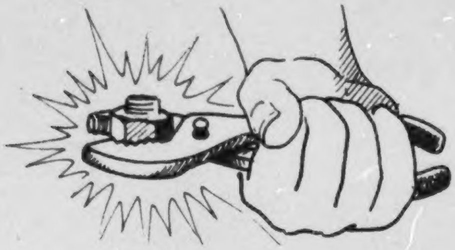
2. Do not hammer on wrenches

3. Do not hammer with wrenches

INFORMATION SHEET

C. Pliers

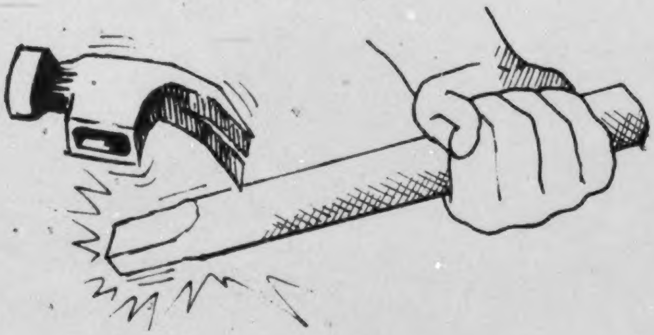
1. Do not use in place of wrench



2. Have handles insulated when working on electrical circuits

D. Hammers

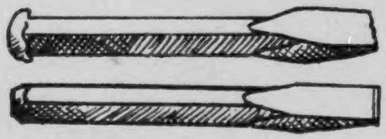
1. Keep handles tight



2. Use the proper type for the job

E. Punches, chisels, and bars

1. Keep cutting edges and points sharp



Before and After Dressing

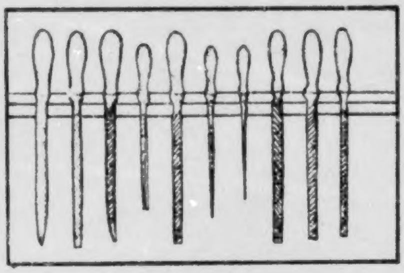
2. Keep head ground to prevent mushrooming

INFORMATION SHEET

F. Files

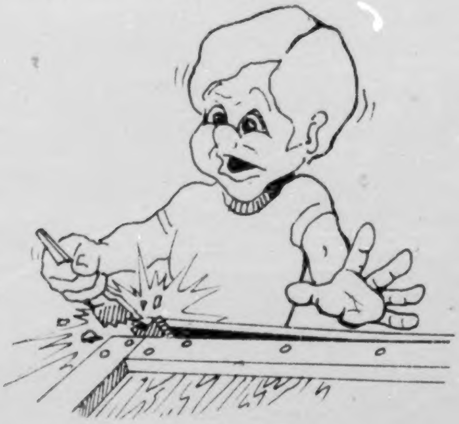
1. Keep files on a wall rack

   (NOTE: They will become dull if stacked in a drawer.)



2. Do not hammer or pry with a file

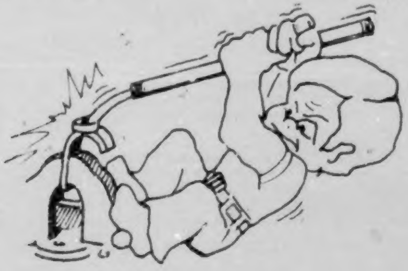
   (NOTE: They are very brittle and will break.)



G. Socket sets

1. Do not use an extension pipe or cheater bar on the handle of a ratchet

   (NOTE: Too much force will strip the gears in the ratcheting mechanism.)



INFORMATION SHEET

2. Do not use a handle and extension pipe with thin wall sockets

   (NOTE: Thin wall sockets will break.)

H. Tubing tools

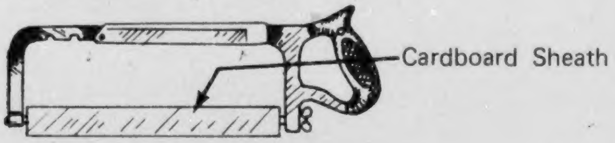
1. Oil threads on flaring tool

2. Replace cutting wheel on cutter when dull

I. Accessory hand tools

1. Drop light cords should not be run over with appliance dollys or other carts

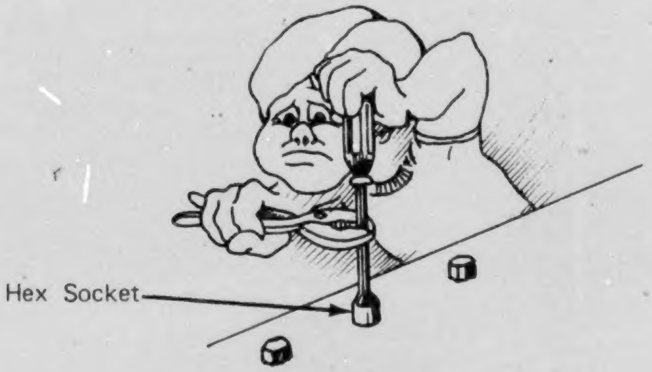
2. Protect the blade on a hack saw with a piece of cardboard to prevent dulling of the teeth



3. Do not use screw starters as a screwdriver

4. Safety glasses should be kept in a case when not in use

5. Nut drivers should only be used on hand tight nuts, bolts, and screws; do not use pliers for increased leverage



INFORMATION SHEET

7. Do not apply too much force to hex key wrenches

   (NOTE: Too much force will break or round out the socket of the set screw.)

J. Threading tools

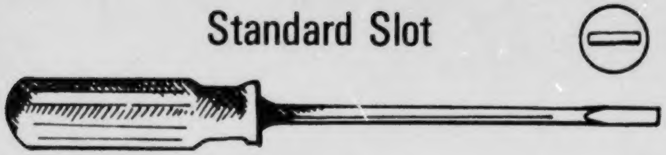
1. Use a few drops of cutting oil when threading

2. Do not keep taps and dies loose in a drawer

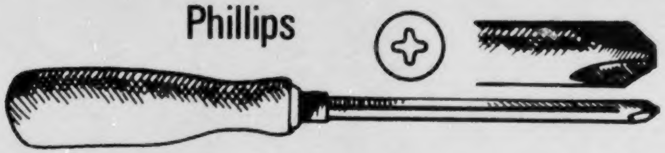
   (NOTE: This will dull the cutting teeth.)

Screwdrivers

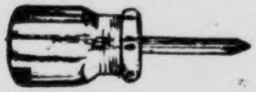
Standard Slot



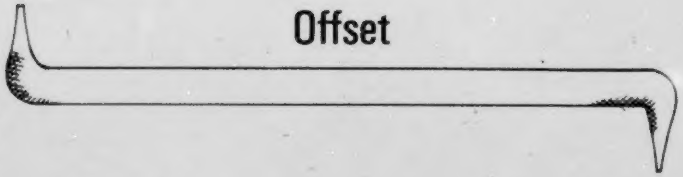
Phillips



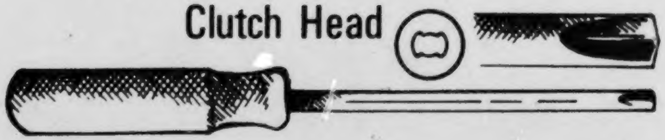
Stubby



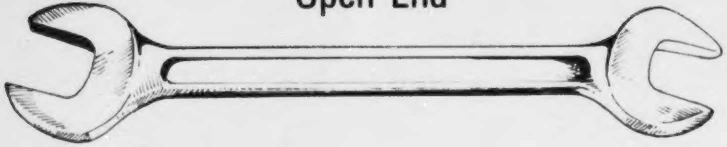
Offset

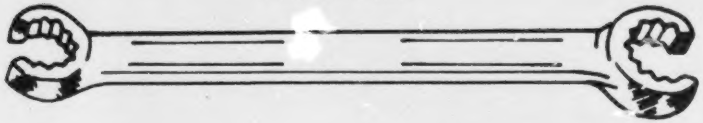


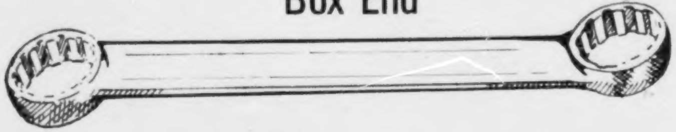
Clutch Head

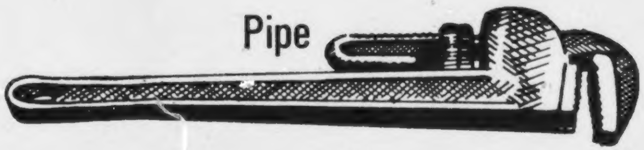


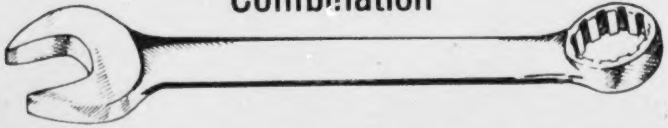
Wrenches

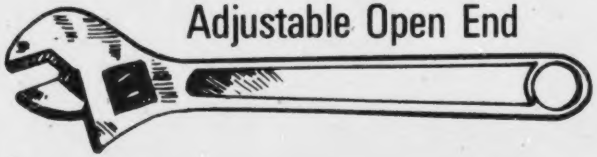

Open End


Flare Nut


Box End

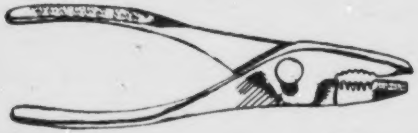

Pipe


Combination

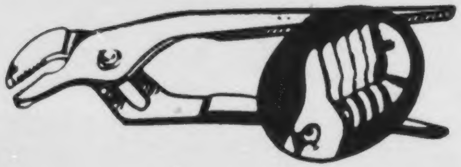

Adjustable Open End

Pliers

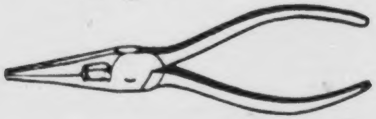
Slip Joint



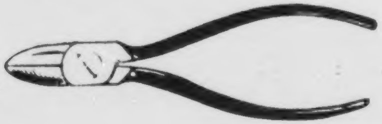
Slip Groove



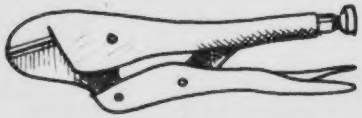
Long Nose



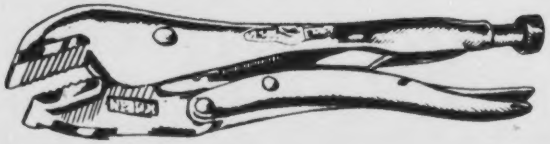
Diagonal Cutters



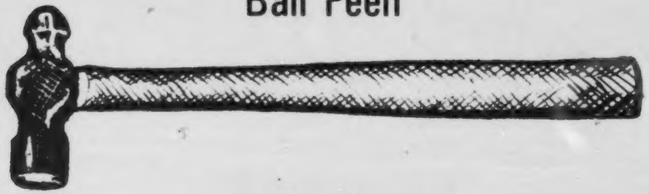
Pinch–Off



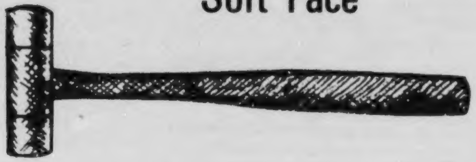
Plier Wrench



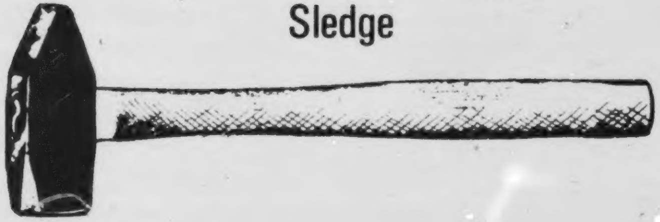
Hammers



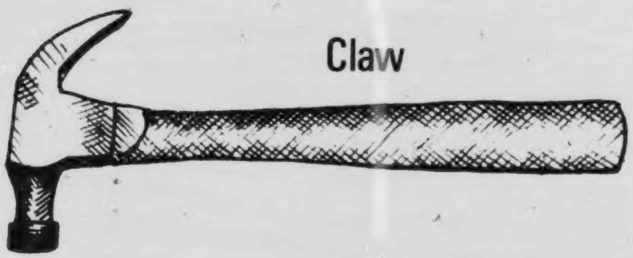
Ball Peen



Soft Face



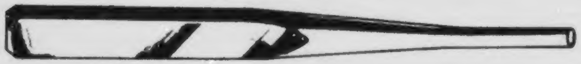
Sledge



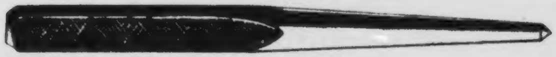
Claw

Punches, Chisels, and Bars

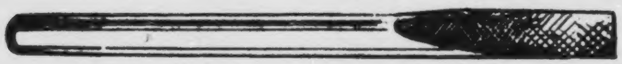
Pin Punch



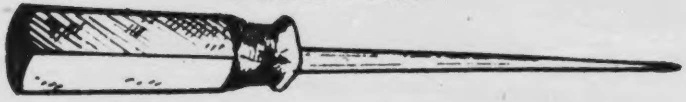
Center Punch



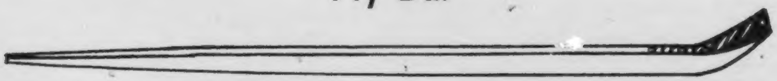
Flat Chisel



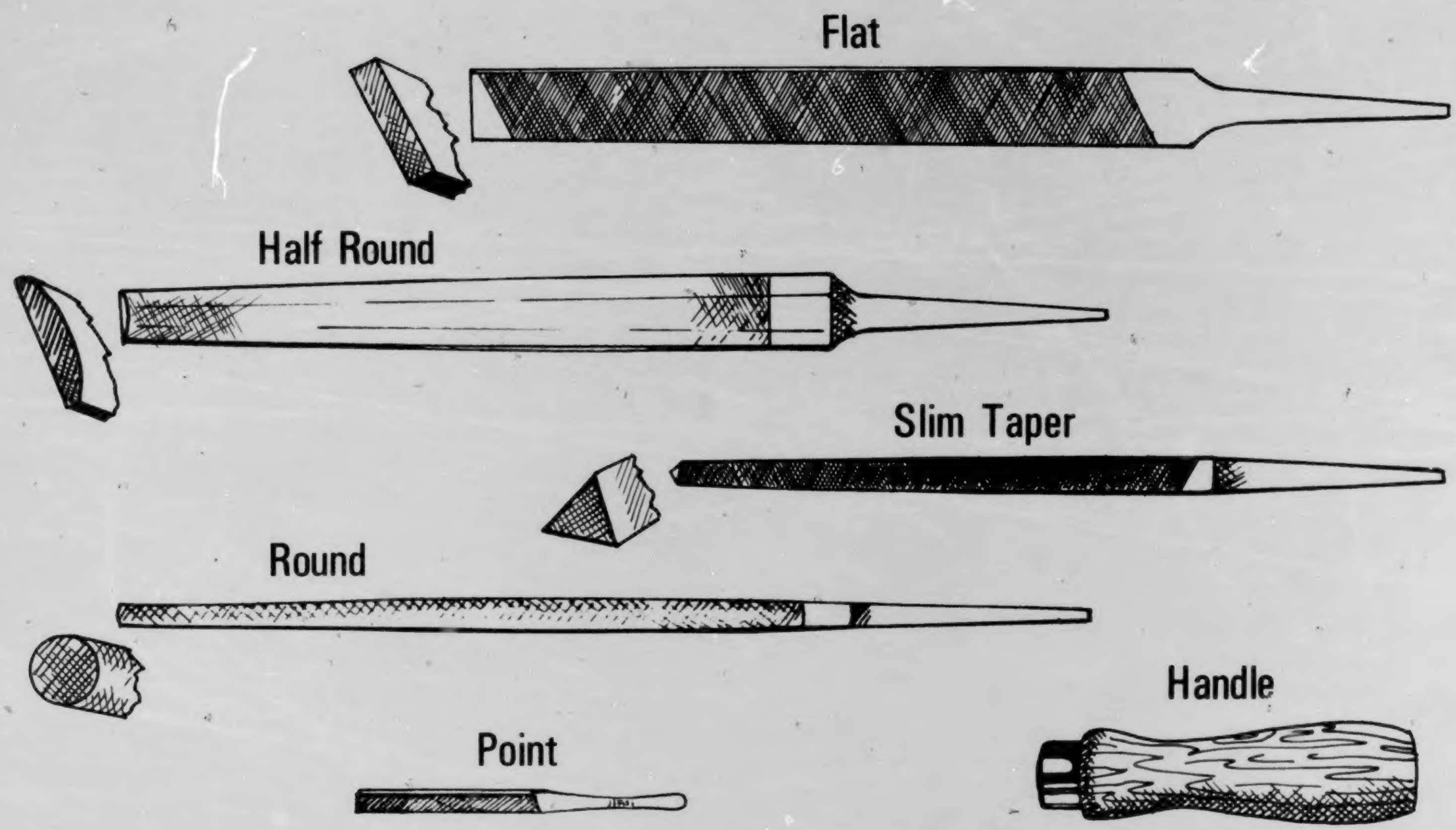
Scratch Awl



Pry Bar

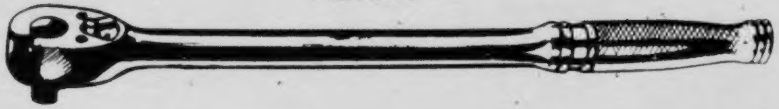


Files

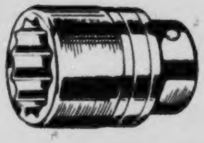

Flat
Half Round
Slim Taper
Round
Handle
Point

Socket Sets

Ratchet

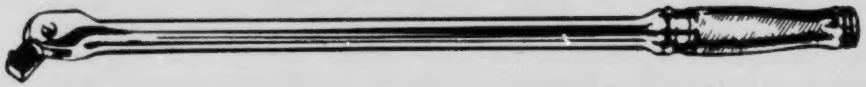


Socket

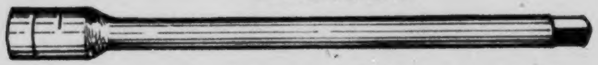


Deep Socket

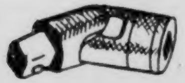
Hinge Handle



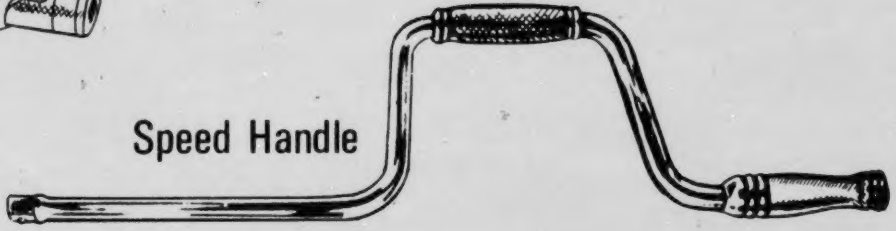
Extension



Universal Joint

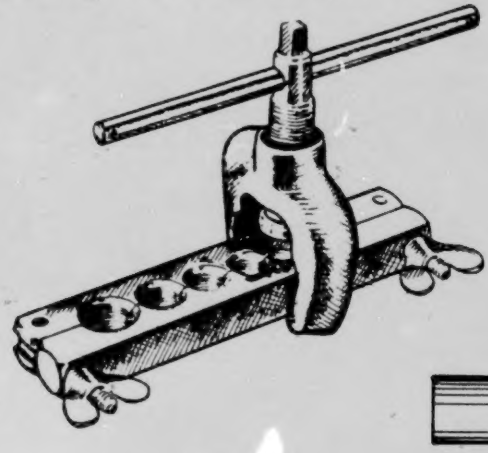


Speed Handle

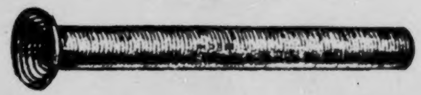


Tubing Tools

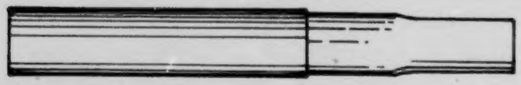
Flaring Tool and Block



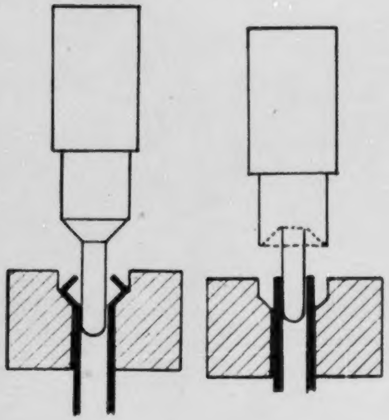
Bending Spring



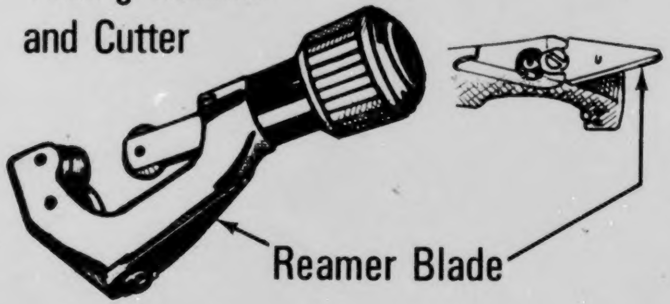
Swage Punch



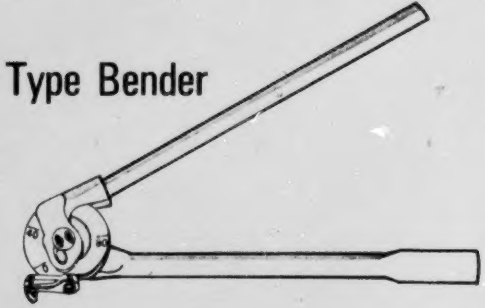
Double Flare Punches



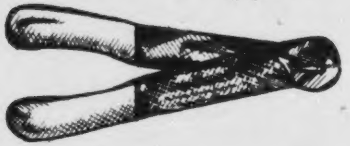
Tubing Reamer and Cutter

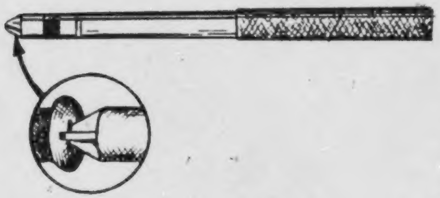


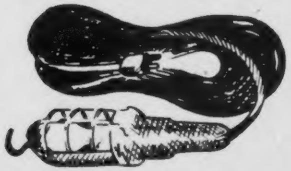
Lever Type Bender

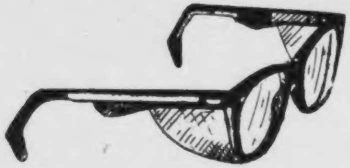


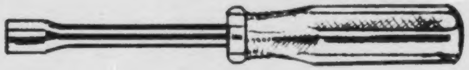
Accessory Hand Tools

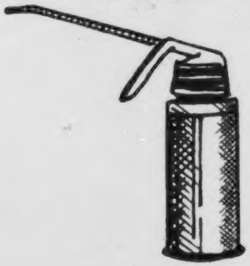

Wire Strippers

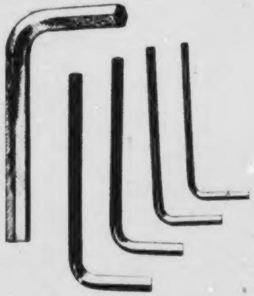

Screw Starter


Drop Light

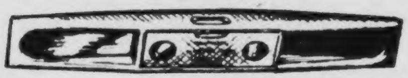

Safety Glasses


Nut Driver


Oil Can

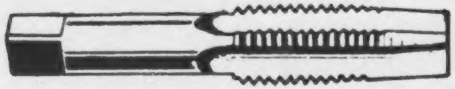

Hex Key Wrenches

Hack Saw

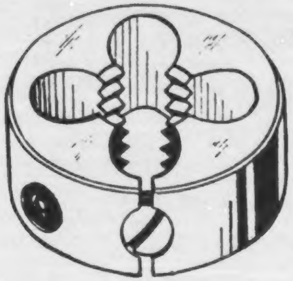

Level

Threading Tools

Tap

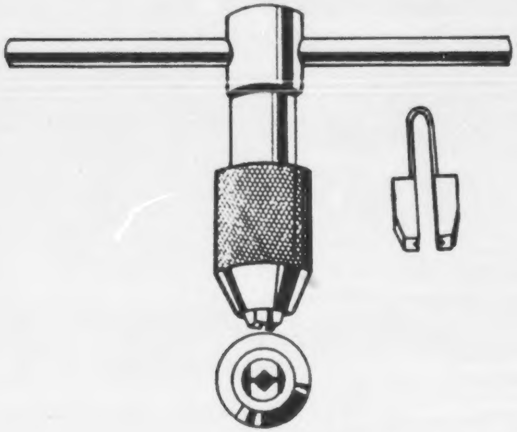


Die

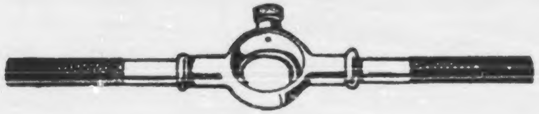


Handles

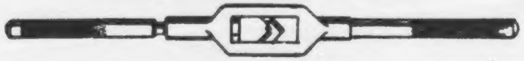
T-Handle Tap Wrench



Die Stock



Hand Tap Wrench



HAND TOOLS
UNIT I

JOB SHEET #1--GRIND A FLAT TIP SCREWDRIVER

I. Tools and materials

   A. Flat tip screwdriver

   B. Bench grinder

   C. Water tray

   D. Safety glasses

II. Procedure

   A. Put on safety glasses

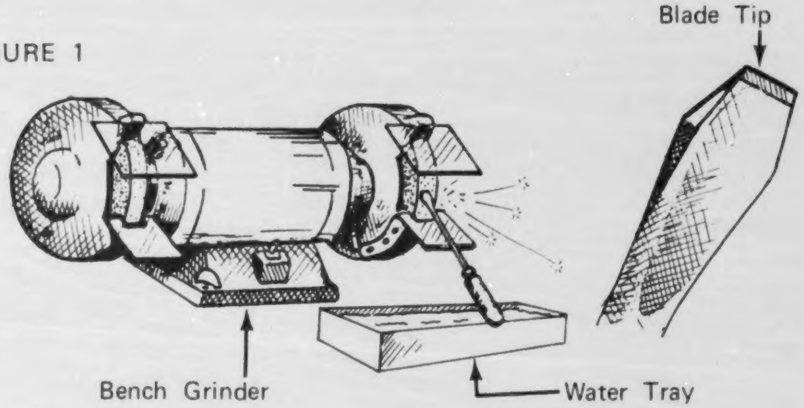
   B. Adjust clearance of tool rest

   (NOTE: Proper clearance is approximately one-eighth inch from grinding wheel.)

   C. Turn on grinder

   D. Grind tip of blade flat (Figure 1)

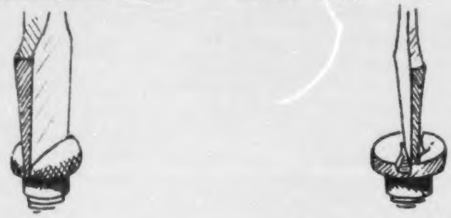
FIGURE 1



JOB SHEET #1

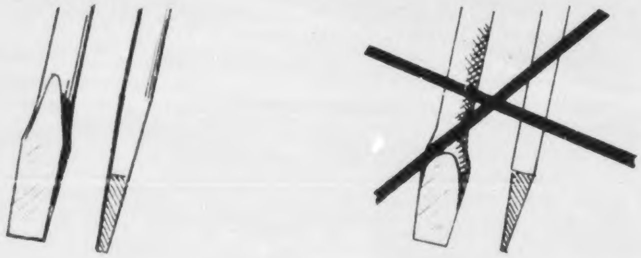
E. Grind sides of blade so blade will fit screw slot (Figure 2)

FIGURE 2



Correct Screwdriver Fit

Poor Fit Damages Screwdriver and Screw Slot



Ground Right

Ground Wrong

F. Cool tip in tray of water often while grinding

(NOTE: Cooling will prevent softening of the tip.)

HAND TOOLS
UNIT I

JOB SHEET #2--GRIND THE HEAD OF CHISEL OR PUNCH

I. Tools and materials

   A. Chisel and/or punch

   B. Bench grinder

   C. Water tray

   D. Safety glasses

II. Procedure

   A. Put on safety glasses

   B. Adjust clearance of tool rest

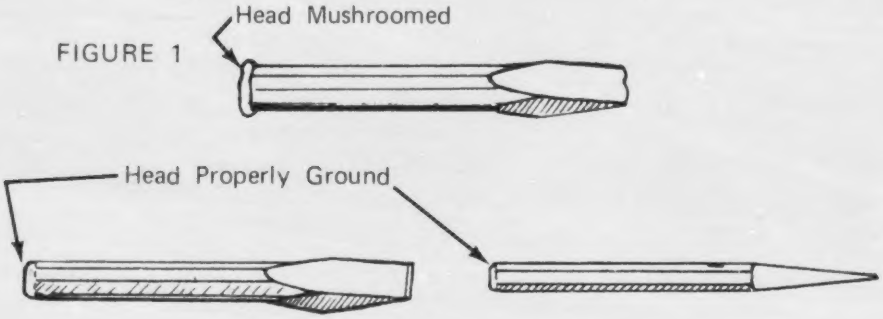
   (NOTE: Proper clearance is approximately one-eighth inch from grinding wheel.)

   C. Turn on grinder

   D. Grind a bevel on the head (Figure 1)

   (NOTE: When the head of a punch or chisel is mushroomed, chips could break off during use causing injury to the user.)

FIGURE 1



HAND TOOLS
UNIT I

JOB SHEET #3--SHARPEN A CHISEL

I. Tools and materials

   A. Chisel

   B. Bench grinder

   C. Water tray

   D. Safety glasses

II. Procedure

   A. Put on safety glasses

   B. Adjust clearance of tool rest

   (NOTE: Proper clearance is approximately one-eighth inch from grinding wheel.)

   C. Turn on grinder

   D. Hold the chisel's cutting edge against the grinding wheel with very little pressure

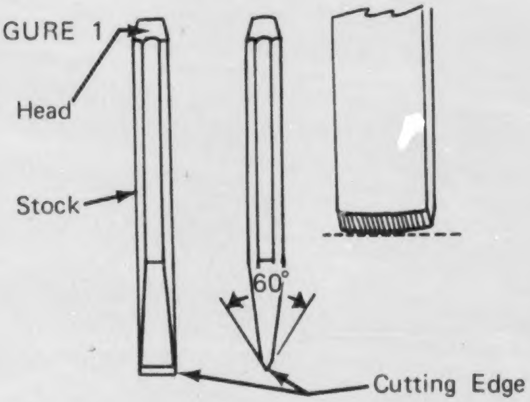
   (NOTE: This will help to prevent overheating of the chisel's cutting edge.)

   E. Dip the chisel in the water frequently to cool

   F. Grind the edge on a slight curve (Figure 1)

   (CAUTION: Hold the chisel with a firm grip during the grinding process.)

FIGURE 1



HAND TOOLS
UNIT I

JOB SHEET #4-CUT EXTERNAL THREADS

I. Tools and materials

  A. Die

  B. Die stock

  C. Vise

  D. Flat file

  E. Oil can

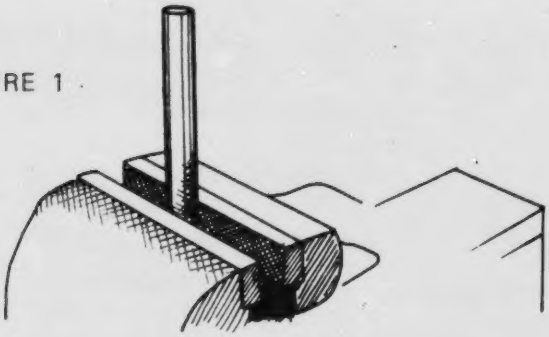
  F. Steel rod

  (NOTE: Ask the instructor what type and size of steel rod to use for this job.)

II. Procedure

  A. Place rod in vise (Figure 1)

FIGURE 1



  B. Chamfer end of rod with file

  C. Lubricate end of rod with cutting oil

  D. Place die in die stock and secure

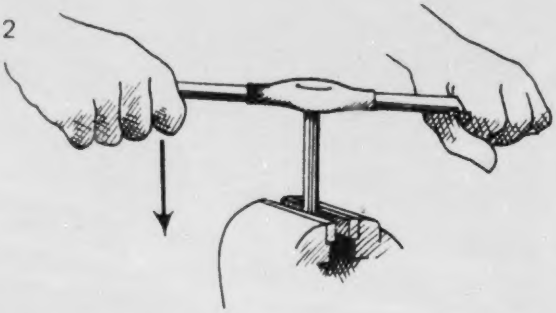
  E. Place die on top of rod with taper facing down

  F. Start die straight on the rod

JOB SHEET #4

G. Press down evenly and turn the die (Figure 2)

FIGURE 2



H. Apply a few drops of cutting oil while turning the die

I. Check die often for squareness

J. Turn the die one turn clockwise and then 1/4 to 1/2 a turn counterclockwise to break the chip

K. Continue this procedure until the desired amount of threads have been cut

L. Remove die by turning counterclockwise

(NOTE: Hold onto the die stock firmly while removing it so as not to drop it when it comes to the end of the threads.)

M. Clean threads with a brush

(CAUTION: Do not use compressed air for cleaning)

N. Clean up tools and put them away

O. Have instructor inspect work

HAND TOOLS
UNIT I

JOB SHEET #5--CUT INTERNAL THREADS

I. Tools and materials

- A. Tap
- B. Tap wrench
- C. Drill motor
- D. Tap drill
- E. Vise
- F. Oil can
- G. Piece of steel to be drilled and tapped

II. Procedure

- A. Place work piece in vise
- B. Drill hole to proper size
- C. Use the chart below to select the proper tap drill

Sizes	Threads Per Inch	Outside Diameter of Screw	Tap Drill Sizes	Decimal Equivalent of Drill
1	64	.073	53	0.0595
2	56	.086	50	0.0700
3	48	.099	46	0.0810
4	40	.112	43	0.0890
5	40	.125	38	0.1015
6	32	.138	33	0.1130
8	32	.164	29	0.1360
10	24	.190	25	0.1495
12	24	.216	16	0.1770
1/4	20	.250	7	0.2010
5/16	18	.3125	F	0.2570
3/8	16	.375	5/16	0.3125
7/16	14	.4375	U	0.3680
1/2	13	.500	27/64	0.4219
9/16	12	.5625	31/64	0.4843
5/8	11	.625	17/32	0.5312
3/4	10	.750	21/32	0.6562
7/8	9	.875	49/64	0.7656

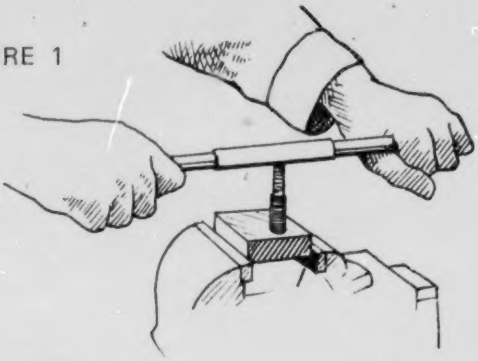
- D. Place tap in tap wrench
- E. Place tap in hole and keep the tap as straight as possible

JOB SHEET #5

F. Apply cutting oil to tap

G. Press down on tap wrench with equal pressure on both sides (Figure 1)

FIGURE 1



H. Make two complete turns with tap

I. Check to see that the tap is straight

J. If tap is not straight, remove it and restart

(NOTE: A slight amount of pressure will be required to get the tap to start straight.)

K. Tap the hole by turning the tap wrench clockwise 1/2 a turn then counterclockwise 1/4 of a turn

L. After the hole is tapped remove the tap by turning the wrench counterclockwise

(NOTE: Hold on to the tap wrench to prevent it from falling on the floor.)

M. Clean tools and put them away

N. Have the instructor inspect

HAND TOOLS
UNIT I

TEST

1. Match the terms on the right to the correct definitions or descriptions.

_____a. Cutting tools consisting of various sizes and shapes which are pushed across a piece of metal to bring it to the proper dimension

_____b. Tool with adjustable jaws used for gripping

_____c. Tool designed to tighten or loosen a hex head bolt or nut

_____d. Tool designed for a particular use

_____e. Type of thread used for precision work

_____f. Tool designed for tightening or loosening a screw or bolt with a recess opening in the head

_____g. Tool which is hand held and is not electrical or specialized

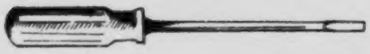
_____h. Tool designed to drive, pound, flatten, or shape an object

_____i. Enlarging of one end of a tube so that the end of another tube the same size will fit into it

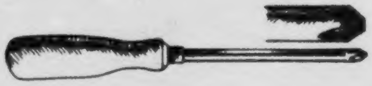
_____j. Type of thread used for general purpose work

1. Pliers
2. Files
3. Specialized tool
4. National Coarse
5. Hammer
6. Hand tool
7. Wrench
8. Swage
9. Screwdriver
10. National Fine

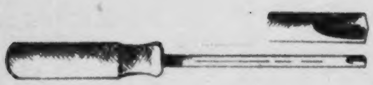
2. Identify the basic hand tools.



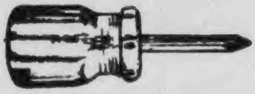
a. ____________________



b. ____________________



c. ______________________



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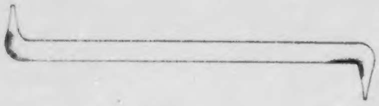

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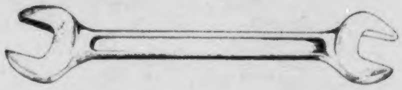

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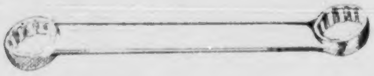

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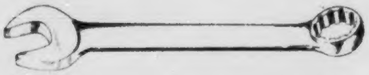

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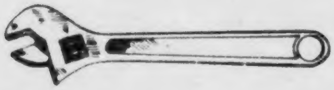

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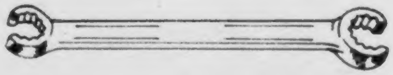

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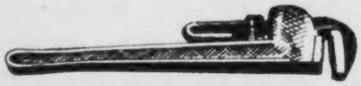

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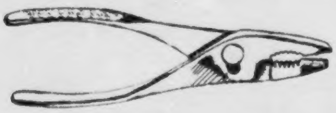

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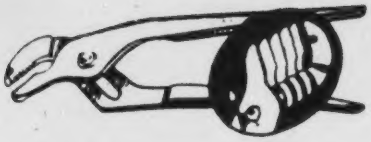

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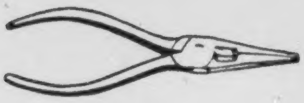

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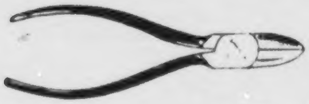

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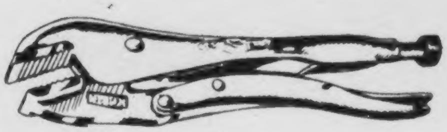

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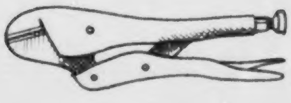

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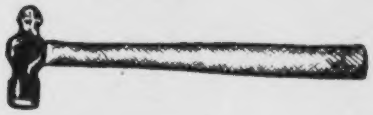

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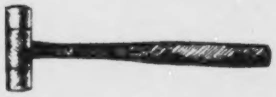

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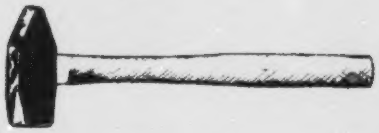

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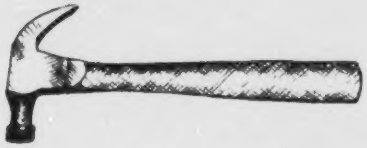

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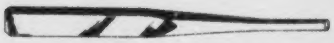

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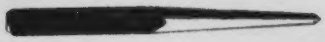

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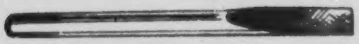

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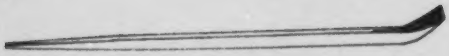

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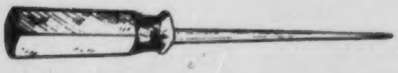

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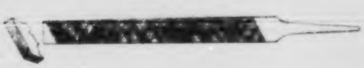

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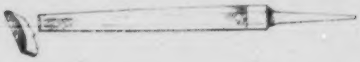

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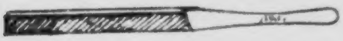

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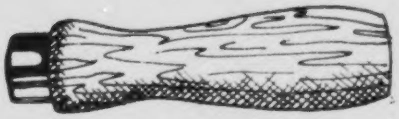

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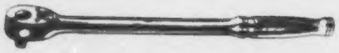

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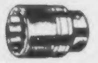

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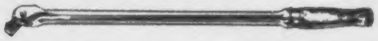

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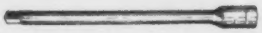

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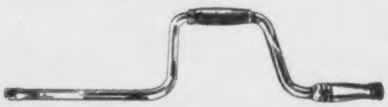

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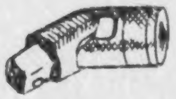

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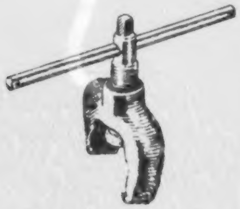

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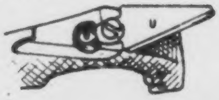

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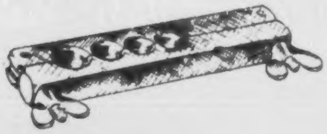

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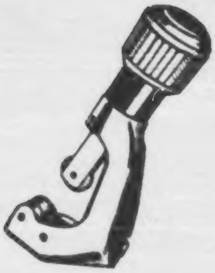

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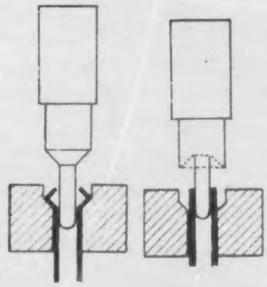

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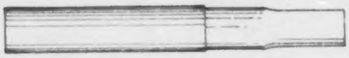

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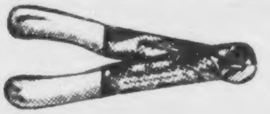

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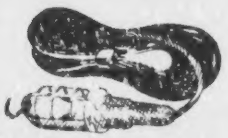

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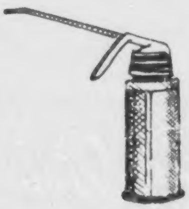

vv. ________________

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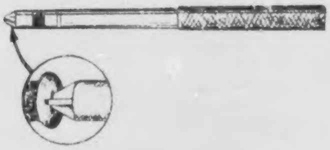

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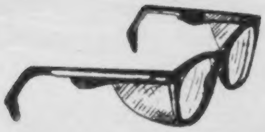

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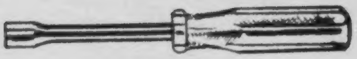

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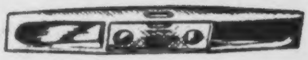

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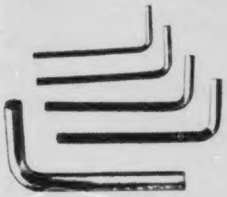

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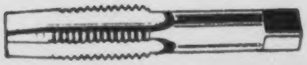

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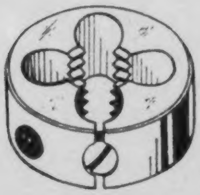

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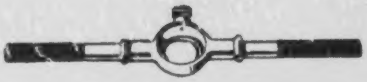

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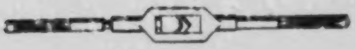

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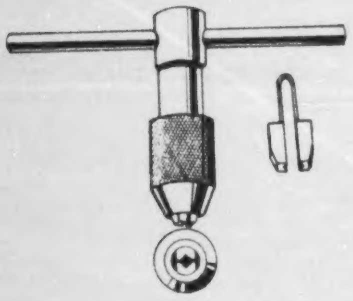

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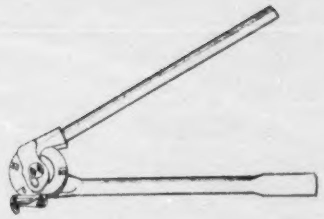

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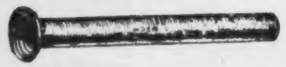
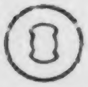


iii. ____________________

3. Select specific tools from similar groups.

   a. Place an "X" by the screwdriver that would fit the screw slot shown.



_____ 1) Standard slot

_____ 2) Phillips

_____ 3) Clutch head

_____ 4) Stubby

_____ 5) Offset

b. Place an "X" by the wrench that is primarily used on rounded surfaces.

_____ 1) Open end

_____ 2) Box end

_____ 3) Combination

_____ 4) Adjustable open end

_____ 5) Pipe

_____ 6) Flare nut

c. Place an "X" by the pliers that are used to crimp refrigeration tubing.

_____ 1) Slip joint

_____ 2) Slip groove

_____ 3) Long nose

_____ 4) Diagonal cutters

_____ 5) Plier wrench

_____ 6) Pinch-off

d. Place an "X" by the hammer that would be used on a brass surface and not mar it.

_____ 1) Ball peen

_____ 2) Soft face

_____ 3) Sledge

_____ 4) Claw

e. Place an "X" by the item that would be used when aligning drive belts.

_____ 1) Pin punch

_____ 2) Center punch

_____ 3) Flat chisel

_____ 4) Pry bar

_____ 5) Scratch awl

f. Place an "X" by the file used generally for cleaning up damaged threads.

_____ 1) Flat

_____ 2) Half round

_____ 3) Round

_____ 4) Point

_____ 5) Slim taper

_____ 6) File handle

g. Place an "X" by the items that are not drive handles.

_____ 1) Ratchet

_____ 2) Socket

_____ 3) Deep socket

_____ 4) Hinge handle

_____ 5) Extension

_____ 6) Speed handle

_____ 7) Universal joint

h. Place an "X" by the items needed to cut a piece of tubing from a roll and double flare one end and swage the other end.

_____ 1) Flaring tool

_____ 2) Tubing reamer

_____ 3) Flare block

_____ 4) Cutter

_____ 5) Double flare punch

_____ 6) Swage punch

_____ 7) Lever type bender

_____ 8) Bending spring

i. Place an "X" by the item that should be used on all jobs.

_____ 1) Wire strippers

_____ 2) Drop light

_____ 3) Oil can

_____ 4) Hack saw

_____ 5) Screw starter

_____ 6) Safety glasses

_____ 7) Nut drivers

_____ 8) Level

_____ 9) Hex key wrenches

j. Place an "X" by the tool that is used for cutting external threads.

_____ 1) Taps

_____ 2) Dies

_____ 3) Handles

4. Discuss the proper care of hand tools.

a. Screwdrivers

b. Wrenches

c. Pliers

d. Hammers

e. Punches, chisels, and bars

f. Files

g. Socket sets

h. Tubing tools

i. Accessory hand tools

j. Threading tools

5. Demonstrate the ability to:

a. Grind a flat tip screwdriver.

b. Grind the head of chisel or punch.

c. Sharpen a chisel.

d. Cut external threads.

Cut internal threads.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

HAND TOOLS
UNIT I

ANSWERS TO TEST

1.

a.	2	f.	9
b.	1	g.	6
c.	7	h.	5
d.	3	i.	8
e.	10	j.	4

2. a. Standard slot screwdriver
   b. Phillips screwdriver
   c. Clutch head screwdriver
   d. Stubby screwdriver
   e. Offset screwdriver
   f. Open end wrench
   g. Box end wrench
   h. Combination wrench
   i. Adjustable open end wrench
   j. Pipe wrench
   k. Flare nut wrench
   l. Slip joint pliers
   m. Slip groove pliers
   n. Long nose pliers
   o. Diagonal cutters
   p. Plier wrench
   q. Pinch-off pliers
   r. Ball peen hammer

s. Soft face hammer

t. Sledge hammer

u. Claw hammer

v. Pin punch

w. Center punch

x. Flat chisel

y. Pry bar

z. Scatch awl

aa. Flat file

bb. Half round file

cc. Round file

dd. Slim taper file

ee. Point file

ff. File handle

gg. Ratchet handle

hh. Socket

ii. Deep socket

jj. Hinge handle

kk. Extension

ll. Speed handle

mm. Universal joint

nn. Flaring tool

oo. Tubing reamer

pp. Flaring block

qq. Cutter

rr. Double flare punch

ss. Swage punch

tt. Wire strippers

uu. Drop light

vv. Oil can

ww. Hack saw

xx. Screw starter

yy. Safety glasses

zz. Nut drivers

aaa. Level

bbb. Hex key wrenches

ccc. Tap

ddd. Die

eee. Die stock

fff. Hand tap wrench

ggg. T-Handle tap wrench

hhh. Lever type bender

iii. Bending spring

3.
a. 3

b. 5

c. 6

d. 2

e. 4

f. 5

g. 2, 3, 5, 7

h. 1, 2, 3, 4, 5, 6

i. 6

j. 2

4. Discussion should include:

a. Screwdrivers

1) Grind flat tip square

2) Discard worn phillips tips

3) Do not hammer on screwdrivers

b. Wrenches

 1) Turn adjustables in proper direction

 2) Do not hammer on wrenches

 3) Do not hammer with wrenches

c. Pliers

 1) Do not use in place of wrench

 2) Have handles insulated when working on electrical circuits

d. Hammers

 1) Keep handles tight

 2) Use the proper type for the job

e. Punches, chisels, and bars

 1) Keep cutting edges and points sharp

 2) Keep head ground to prevent mushrooming

f. Files

 1) Keep files on a wall rack

 2) Do not hammer or pry with a file

g. Socket sets

 1) Do not use an extension pipe or cheater bar on the handle of a ratchet

 2) Do not use a handle and extension pipe with thin wall sockets

h. Tubing tools

 1) Oil threads on flaring tool

 2) Replace cutting wheel on cutter when dull

i. Accessory hand tools

 1) Drop light cords should not be run over with appliance dollys or other carts

 2) Protect the blade on a hack saw with a piece of cardboard to prevent dulling of the teeth

3) Do not use screw starters as a screwdriver

4) Safety glasses should be kept in a case when not in use

5) Nut drivers should only be used on hand tight nuts, bolts, a
screws; do not use pliers for increased leverage

6) Levels should never be dropped

7) Do not apply too much force to hex key wrenches

j. Threading tools

1) Use a few drops of cutting oil when threading

2) Do not keep taps and dies loose in a drawer

5. Performance skills evaluated to the satisfaction of the instructor

SPECIAL TOOLS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify, use, and care for the specialized tools used in the air-conditioning and refrigeration trade. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with specialized tools to the correct definitions.
2. Identify specialized tools.
3. Describe the use of the specialized tools.
4. Describe the care of the specialized tools.
5. Identify the components of the refrigeration gauge set.
6. List when each refrigeration gauge set component is used.
7. Demonstrate the ability to sharpen a twist drill bit.

SPECIAL TOOLS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedure outlined in the job sheet.

   G. Show students special tools.

   H. Take field trip to a parts wholesaler.

   I. Have students look up tools in catalogs to get an idea of the cost involved in equipping a shop.

   J. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheet.

   D. Complete activities assigned by instructor.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

C. Transparency masters

1. TM 1--Special Tools
2. TM 2--Special Tools (Continued)
3. TM 3--Special Tools (Continued)
4. TM 4--Special Tools (Continued)
5. TM 5--Special Tools (Continued)
6. TM 6--Special Tools (Continued)
7. TM 7--Special Tools (Continued)
8. TM 8--Special Tools (Continued)
9. TM 9--Refrigeration Gauge Set Components

D. Job Sheet #1--Sharpen a Twist Drill Bit

E. Test

F. Answers to test

II. Reference--Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Co., 1975.

SPECIAL TOOLS
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Charging--Replacing or adding refrigerant to a refrigeration system

   B. Evacuating--Using a vacuum pump to pull a vacuum on a refrigeration system for the purpose of removing air and moisture

   C. Conduit--Tubular enclosure for electrical conductors

   D. Thermal electric lead--Lead made up of two dissimilar metals which creates a small amount of voltage upon temperature change

   E. Hygrometer--Humidity sensing device

   F. High vacuum--Vacuum of 2000 to .1 microns and requires a two stage pump; also called a deep vacuum

   (NOTE: One inch of mercury vacuum is equal to 25,400 microns.)

   G. Manometer--Instrument consisting of a "U" shaped glass tube with either mercury or water in it for the measurement of pressure gases

   H. Hermetic--Sealed system

   I. Combustion--Burning of fuels

II. Specialized tools (Transparencies 1, 2, 3, 4, 5, 6, 7, and 8)

   A. Refrigeration gauge set

   B. Leak detectors

      1. Soap solution

      2. Halide torch

      3. Electronic

   C. Drill motors

      1. Straight

      2. Offset

INFORMATION SHEET

D. Drill bits
    1. Twist
    2. Wood
    3. Masonry
E. Bench grinders
F. Vises
    1. Bench
    2. Pipe
G. Pullers
    1. Wheel
    2. Bearing
    3. Gear
H. Thermometers
    1. Pocket
    2. Remote bulb
    3. Flue and stack
    4. Thermal electric
I. Recording thermometers
    1. Manual wind
    2. Electric
J. Hygrometers
    1. Sling psychrometer
    2. Dial type
    3. Humidity recorder

INFORMATION SHEET

K. Vacuum pumps
    1. Low vacuum
    2. High vacuum
L. Vacuum indicators
    1. Compound gauge
    2. Mercury manometer
    3. Thermocouple micron gauge
M. Capillary tube cleaners
    1. Manual
    2. Hydraulic
N. Charging cylinder
O. Service valves
    1. Hermetic service valve kit
    2. Access core type valves
    3. Process tube adapters
    4. Line piercing valves
P. Scales
Q. Fin combs
R. Oil pump
S. Combustion testing kit
T. Air meters
    1. Aneometer
    2. Pitot tube
    3. Incline manometer
U. Appliance truck

INFORMATION SHEET

V. Knock-out cutter

W. Combination pattern snips

X. Hand notcher

Y. Hand seamer

Z. Riveter

AA. Riveting hammer

BB. Aviation snips

  1. Right-hand

  2. Left-hand

CC. Double cutting snips

DD. Hand crimper

EE. Refrigeration ratchet

III. Use of specialized tools

A. Refrigeration gauge set--For charging, evacuating, and checking pressures on refrigerant systems

B. Leak detectors--For locating refrigerant leaks

C. Drill motors

  1. Straight--For drilling holes in metal or wood

  2. Offset--For drilling holes in metal or wood in limited working space

D. Drill bits

  1. Twist--For drilling metal

  2. Wood--For drilling wood

  3. Masonry--For drilling concrete and stone

E. Bench grinders--For grinding metal edges

INFORMATION SHEET

F. Vises

1. Bench--For holding objects secure

   Example: An object would need to be held secure while it was being drilled, filed, sawed, or electrically tested

2. Pipe--For holding pipe or conduit secure

   Example: Pipe or conduit would need to be held secure when it is being cut, threaded, or reamed

G. Pullers

1. Wheel--For removing pulleys and bearings from motor shafts

2. Bearing--For removing or installing bearings and bushings in motors

3. Gear--For removing small pulleys or gears from motor shafts

H. Thermometers

1. Pocket--For checking the temperature of refrigeration components and systems

2. Remote bulb--For checking temperatures in one area and reading the temperature on a dial in another area

   (NOTE: The pocket and remote bulb thermometers are available in various ranges but the -40°F to +120°F range seems to be the most applicable to refrigeration work.)

3. Flue and stack--For checking the temperatures created in gas flues and stacks

   (NOTE: The temperature range on these thermometers is generally 200°F to 1000°F.)

4. Thermal electric--For measuring temperatures from -50°F to as high as +1000°F

   (NOTE: This temperature indicating meter is generally capable of checking more than one temperature through the use of multiple leads and by changing the function switch.)

INFORMATION SHEET

I. Recording thermometers

1. Manual wind--Records temperatures on a time chart

   (NOTE: This recorder can be equipped with a remote temperature sensing bulb, and it has a manual wind clock assembly for advancing the time chart.)

2. Electric--Records temperatures on a strip chart

   (NOTE: This recorder uses thermocouple type leads and will generally record more than one temperature.)

J. Hygrometers

1. Sling psychrometer--Wet-bulb and dry-bulb temperatures will be obtained by whirling the psychrometer for 15 to 20 seconds

   (NOTE: Dry-bulb temperature is the temperature of the air as indicated by an ordinary thermometer. The wet-bulb temperature is the temperature by evaporation.)

2. Dial type--Contains human hair that reacts to humidity changes which gives a meter reading

3. Humidity recorder--Records humidity changes on a time chart

K. Vacuum pumps

1. Low vacuum--For evacuating a refrigeration system; used in conjunction with a gauge manifold

2. High vacuum--For evacuating a refrigeration system; used in conjunction with a high vacuum gauge manifold and micron gauge

   (NOTE: These pumps are capable of pulling a vacuum below 50 microns and are used on large air-conditioning and refrigeration systems.)

L. Vacuum indicators

1. Compound gauge--Indicates vacuum accurately to 25 inches of mercury

2. Mercury manometer--Indicates an accurate vacuum reading below 25 inches; used with a vacuum pump

3. Thermocouple micron gauge--An extremely accurate vacuum indicator; used in conjunction with a high vacuum pump

INFORMATION SHEET

M. Capillary tube cleaner

   1. Manual--Forces oil or R-11 through a capillary tube when the pressure handle is turned clockwise

   2. Hydraulic--Forces oil or R-11 through a capillary tube with the use of a hydraulic pump

      (NOTE: Remove capillary tubes from system before cleaning.)

N. Charging cylinder--For charging the proper amount of refrigerant into a system; used with a gauge manifold set

O. Service valves

   1. Hermetic service valve kit--Allows the connection of refrigeration gauges to some hermetic systems

      (NOTE: This valve kit is essential when servicing General Electric or Frigidaire domestic refrigerators.)

   2. Access core type valves--Allow the refrigerant system pressures to be checked when the gauge hose depresses the core

      (NOTE: These valves are commonly referred to as Schrader valves)

   3. Process tube adapters--Provide a gauge connection by fitting onto the end of the charging stubs

      (NOTE: These adapters must be removed after the stub has been pinched off and prior to soldering end of stub.)

   4. Line piercing valves--Allow a gauge connection by tightening onto a charging stub and piercing it

      (NOTE: These valves are commonly referred to as line taps.)

P. Scales--For weighing the amount of refrigerant during the charging process

Q. Fin combs--For straightening the heat transfer fins on condensers and evaporators

R. Oil pump--For putting oil into a compressor without the danger of contamination

INFORMATION SHEET

S. Combustion testing kit--For servicing gas or oil furnaces to detect CO_2 content, draft, stack temperature, and smoke

T. Air meters

   1. Aneometer--Measures the speed of the air being supplied through a grille

      (NOTE: This measurement is expressed in feet per minute.)

   2. Pitot tube--Determines air speed by obtaining air pressure through a grille

      (NOTE: This instrument is used in conjunction with a direct reading meter or an incline manometer.)

   3. Incline manometer--Used with a pitot tube to determine air velocity pressure and static pressure

U. Appliance truck--For moving refrigerators and other heavy equipment

V. Knock-out cutter--For making holes in sheet metal

   (NOTE: This cutter is primarily used for making holes in cabinets for electrical conduit and refrigerant lines.)

W. Combination pattern snips--For all general purpose cutting of sheet metal

   (NOTE: The blades of the combination snips are designed to permit the metal to curve up out of the way when making circular cuts.)

X. Hand notcher--For cutting notches in the edge of sheet metal

Y. Hand seamer--For forming a seam on a piece of sheet metal, by hand

Z. Riveter--For riveting pieces of sheet metal together

AA. Riveting hammer--For forming the sheet metal

   (NOTE: The edges are beveled to prevent marking of the metal.)

BB. Aviation snips

   1. Right-hand--For cutting sheet metal in a right-handed direction

INFORMATION SHEET

2. Left-hand--For cutting sheet metal in a left-handed direction

   (NOTE: The right-hand and left-hand snips can be distinguished by the position of the upper blade. When the snips are held in a position to cut the metal, if the upper blade is on the operator's right, then they are right-hand snips. If, in this position, the upper blade is on the left, they are left-hand snips.)

CC. Double cutting snips--For cutting sheet metal where both pieces of metal must lay flat

DD. Hand crimper--For crimping the end of sheet metal pipe so that sections may be fitted together

EE. Refrigeration ratchet--For front seating and back seating service valves and acetylene cylinder valves

IV. Care of specialized tools

A. Refrigeration gauge set

1. Keep hoses plugged

2. Check gauge calibration

3. Oil manifold hand valve stems twice a year

   (NOTE: Two drops of oil on each shaft is sufficient.)

4. Replace gauge lenses if cracked or broken

   (NOTE: Do not allow oil from refrigeration system to enter manifold gauge because this will damage the gauge.)

B. Leak detectors

1. Clean orifice and hose of halide torch

2. Electronic leak detectors

   a. Do not drop

   b. Keep probe clean

   c. Do not use around a heavy concentration of refrigerant

INFORMATION SHEET

C. Drill motors

  1. Check for defective cord
  2. Do not overload
  3. Keep motor cooling openings clear
  4. Do not drop
  5. Do not lift by cord

D. Drill bits

  1. Keep sharp
  2. Do not force or bend
  3. Use a few drops of cutting oil when drilling heavy metal
  4. Do not use wood bits for sheet metal
  5. Use water as a coolant when drilling concrete or stone

E. Bench grinders

  1. Keep safety shield clean and in place
  2. Keep tool rest tight
  3. Tell instructor when grinding wheel needs to be dressed

F. Vises

  1. Keep clean
  2. Oil clamping screw
  3. Do not hammer on jaws
  4. Do not overtighten

G. Pullers

  1. Keep tip pointed
  2. Oil threaded shaft
  3. Do not drop

INFORMATION SHEET

H. Thermometers

1. Do not drop
2. Do not kink remote bulb capillaries
3. Use only in proper temperature range
4. Keep pocket thermometers in case when not in use
5. Check batteries on thermal electric

I. Recording thermometers

1. Do not drop
2. Do not wind clock too tight on manual wind
3. Place recorder where it will not be knocked off

J. Hygrometers

1. Do not drop
2. Use distilled water on wet-bulb wick
3. Keep in case when not in use
4. Change wick frequently

K. Vacuum pumps

1. Change oil often

   (NOTE: Vacuum pump manufacturers recommend changing the oil after every evacuation.)

2. Keep clean

L. Vacuum indicators

1. Do not drop
2. Keep clean
3. Store in safe place when not in use

INFORMATION SHEET

M. Capillary tube cleaner

  1. Keep clean

  2. Do not overpressurize gauge on hydraulic pump type

N. Charging cylinders

  1. Keep clean

  2. Do not drop or knock over

  3. If refrigerant is left in cylinder, tag it as to type of refrigerant

  4. Do not heat with a torch

O. Service valves

  1. Do not overtighten hermetic service valves

     (NOTE: Overtightening will cause the valve adapters that are used with the hermetic service valve kit to break.)

  2. Do not overtighten valve cores

     (NOTE: Overtightening will strip out the valve cores.)

  3. Remove line piercing valves after system servicing is over

P. Scales

  1. Do not try to weigh objects heavier than the limits of the scales

  2. Do not try to weigh objects with the scale dial in the locked position

Q. Fin combs-Do not drop

(NOTE: Dropping will alter the preset spacing of the comb teeth.)

R. Oil pump

  1. Keep clean

  2. Put away when not in use

  3. Always replace cap to prevent oil contamination

INFORMATION SHEET

S. Combustion testing kit
  1. Read instructions included in kit
  2. Store in a safe place when not in use

T. Air meters
  1. Do not drop
  2. Store in a safe place when not in use

U. Appliance truck
  1. Lubricate wheel bearings
  2. Roll strap up on ratchet when not being used
  3. Oil ratchet mechanism every three months
  4. Move only objects the truck can support

V. Knock-out cutter
  1. Do not drop
  2. Use only on proper gauge metal

W. Combination pattern snips
  1. Do not throw or drop
  2. Keep sharp
  3. Oil swivel point

X. Hand notcher
  1. Use only on proper gauge metal
  2. Oil
  3. Do not throw or drop

Y. Hand seamer
  1. Keep clean and oiled
  2. Do not throw or drop

Z. Riveter

   1. Keep clean and oiled

   2. Do not throw or drop

AA. Riveting hammer

   1. Do not throw or drop

   2. Keep handle tight

BB. Aviation snips

   1. Do not throw or drop

   2. Keep sharp

   3. Keep oiled and clean

CC. Double cutting snips

   1. Do not throw or drop

   2. Keep sharp

   3. Keep oiled and clean

DD. Hand crimper

   1. Do not throw or drop

   2. Keep oiled and clean

EE. Refrigeration ratchet

   1. Do not apply excessive force on ratchet mechanism

   2. Oil

   3. Do not use as a hammer

V. Refrigeration gauge set components (Transparency 9)

A. Gauge manifold

   1. Body

   2. Hand valves

INFORMATION SHEET

   3. Hose ports
   4. Gauge ports

B. Compound gauge
   1. Pressure 0 - 200 p.s.i.g.
   2. Vacuum 0 - 30 inches of mercury
   3. Recalibration screw
   4. Lens

C. Pressure gauge
   1. Pressure 0 - 500 p.s.i.g.
   2. Recalibration screw
   3. Lens

D. Refrigerant hose
   1. Neoprene
   2. 1/4" female flare ends
   3. Valve core depressors

E. Hose holder
   1. Fits on manifold
   2. 1/4" male flare fittings
   3. Hook

VI. Use of refrigeration gauge set components

A. Gauge manifold
   1. Charging
   2. Evacuating
   3. Checking pressures

INFORMATION SHEET

B. Compound gauge

1. Charging vapor
2. Evacuating
3. Pressurizing
4. Checking low side pressures

C. Pressure gauge

1. Charging into high side
2. Evacuating through both sides
3. Pressurizing
4. Checking high side pressures

D. Refrigerant hoses

1. Charging
2. Evacuating
3. Pressurizing
4. Checking pressures

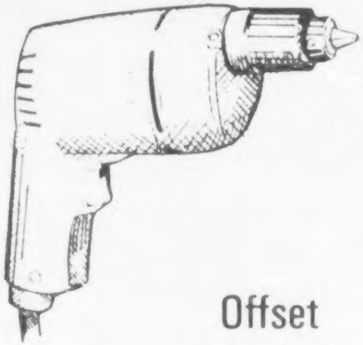
E. Hose holder

1. Keeping hoses clean
2. Holding hoses when not in use

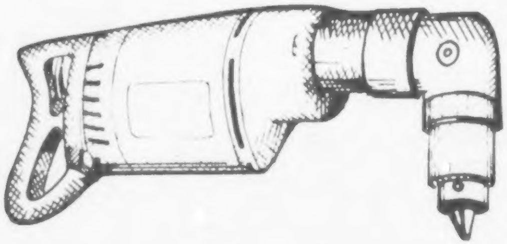
Special Tools

Drill Motors

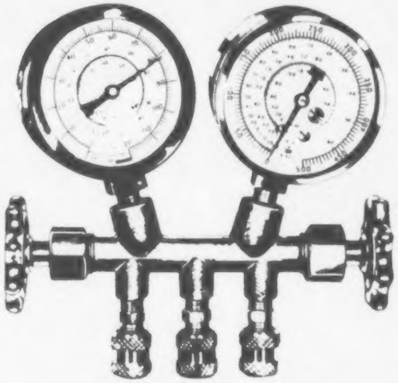
Straight



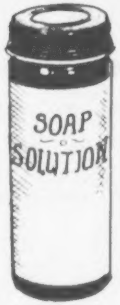
Offset



Refrigeration Gauge Set

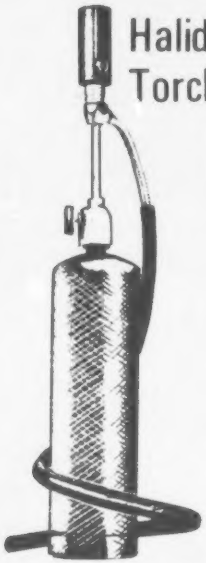


Leak Detectors

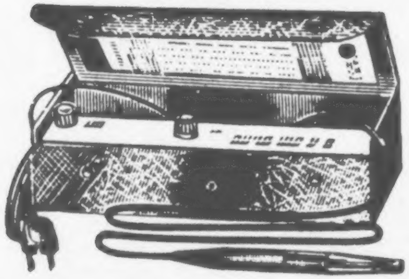


Soap Solution

Halide Torch



Electronic

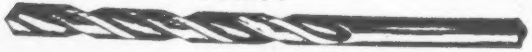


Special Tools

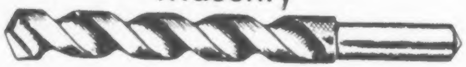
(Continued)

Drill Bits

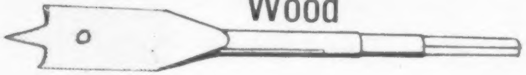
Twist



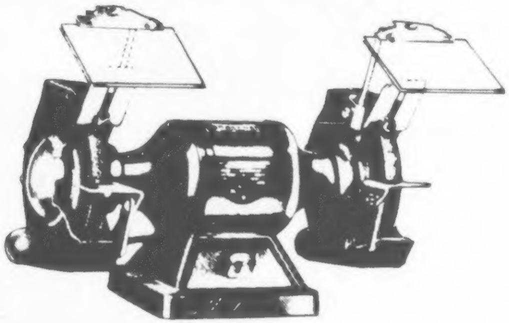
Masonry



Wood

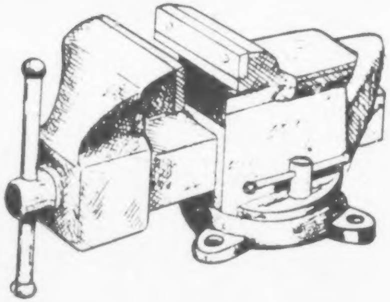


Bench Grinder

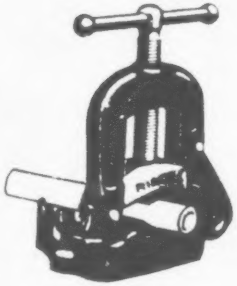


Vises

Bench

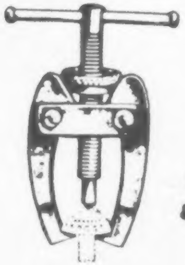


Pipe

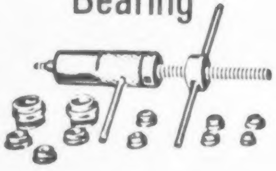


Pullers

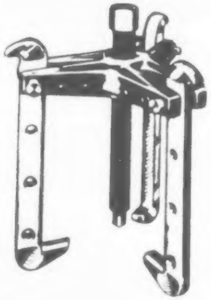
Gear



Bearing



Wheel

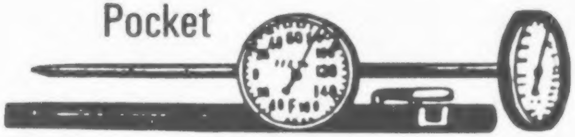


Special Tools

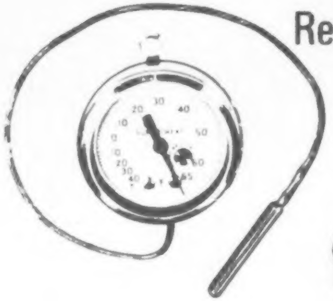
(Continued)

Thermometers

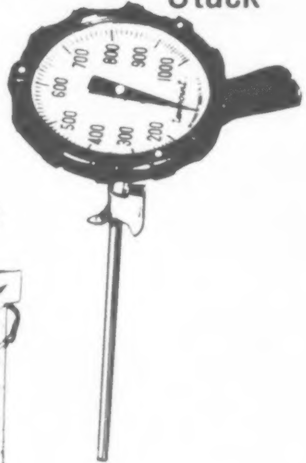
Pocket



Remote Bulb



Flue and Stack


200
300
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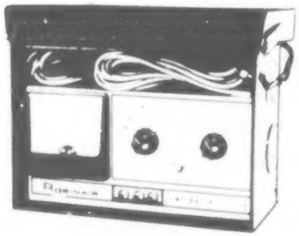
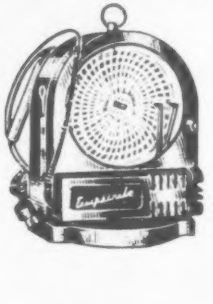
1000

Thermal Electric

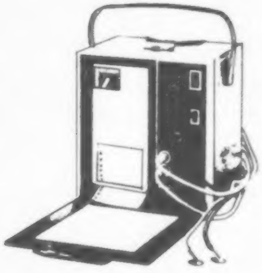


Recording Thermometers

Manual Wind

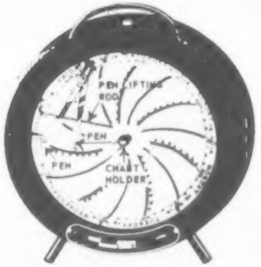


Electric

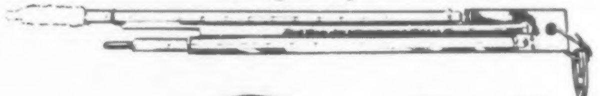


Hygrometers

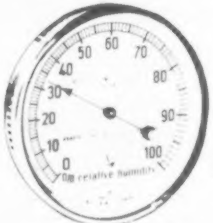
Humidity Recorder


PEN LIFTING ROD
PEN
PEN
CHART HOLDER

Sling Psychrometer



Dial Type

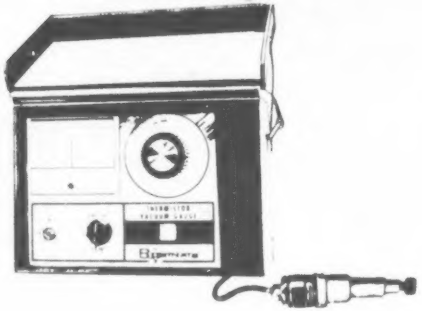

0
10
20
30
40
50
60
70
80
90
100
relative humidity

Special Tools

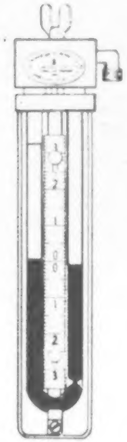
(Continued)

Vacuum Indicators

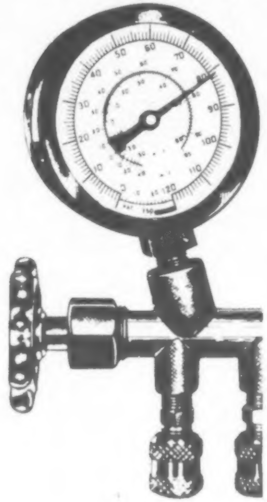
Thermocouple Micron Gauge



Mercury Manometer

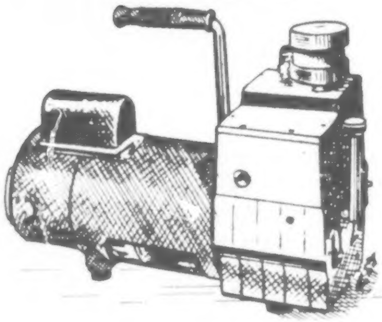


Compound Gauge

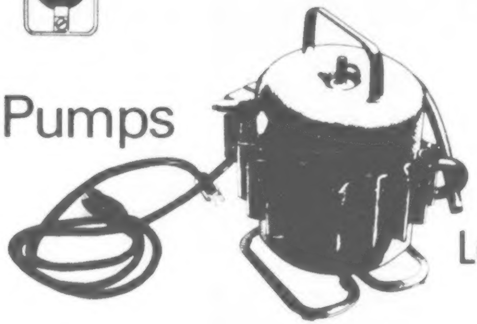


Vacuum Pumps

High Vacuum



Low Vacuum

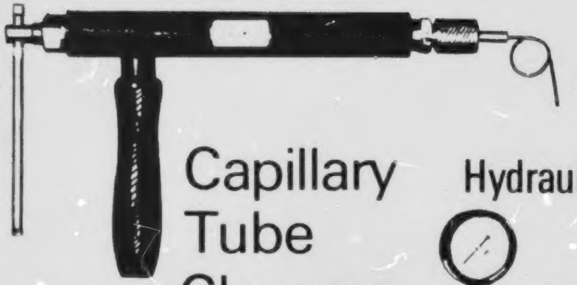


Special Tools

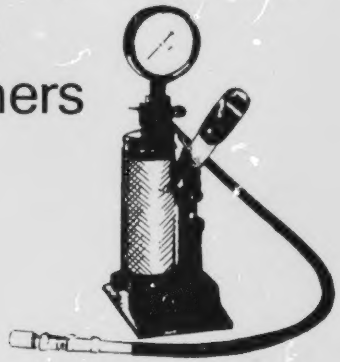
(Continued)

Capillary Tube Cleaners

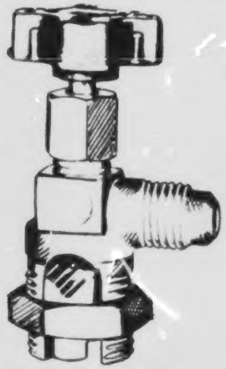
Manual



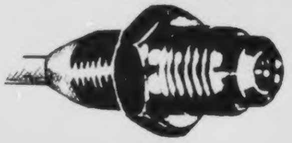
Hydraulic



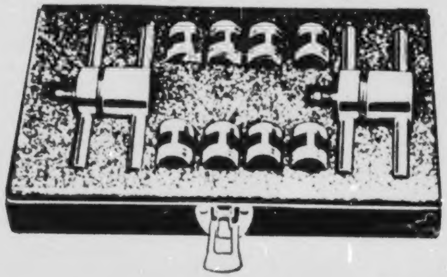
Line Piercing Valve



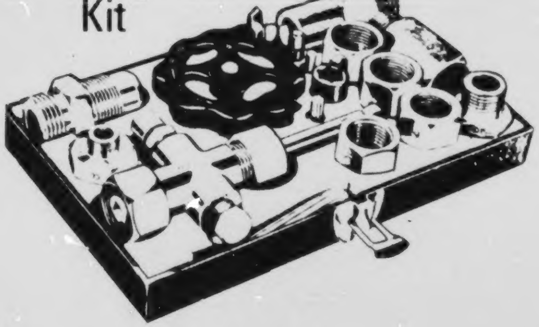
Access Core Type Valve



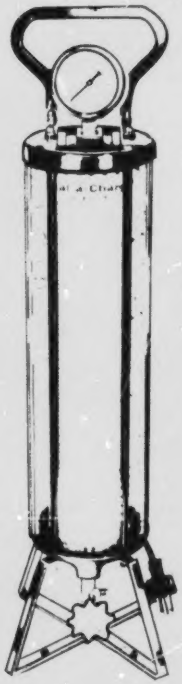
Process Tube Adapters



Hermetic Service Valve Kit



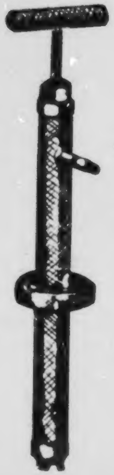
Charging Cylinder



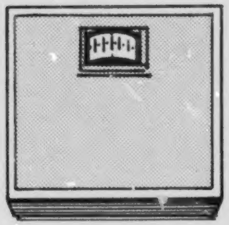
Special Tools

(Continued)

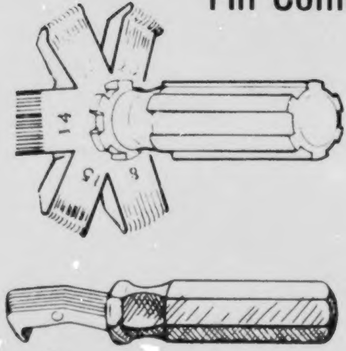
Oil Pump



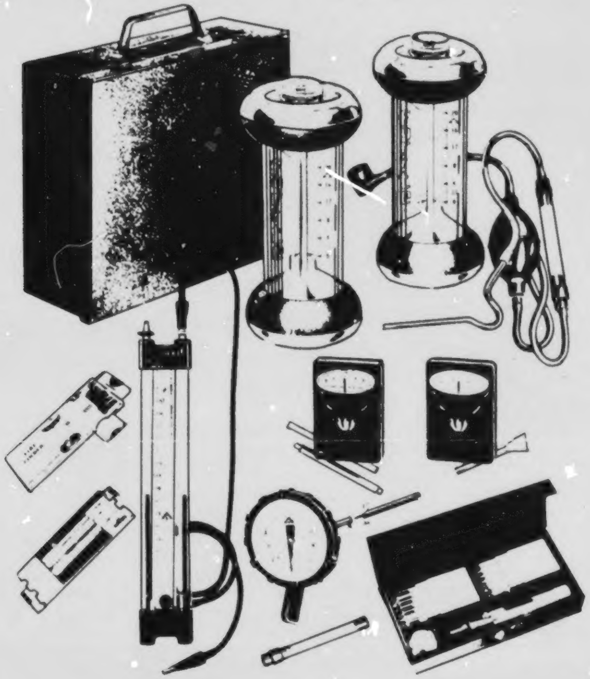
Scales



Fin Combs



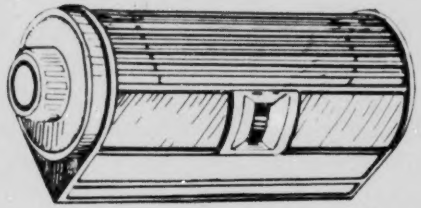
Combustion Testing Kit



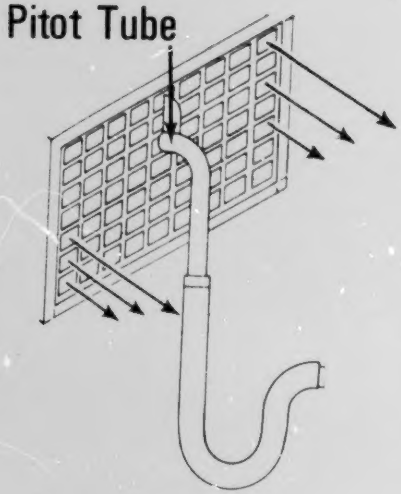
Special Tools

(Continued)

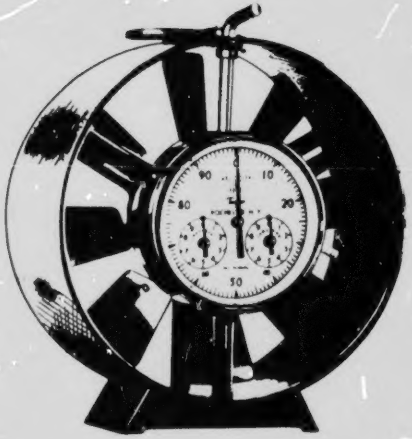
Aneometer



Pitot Tube

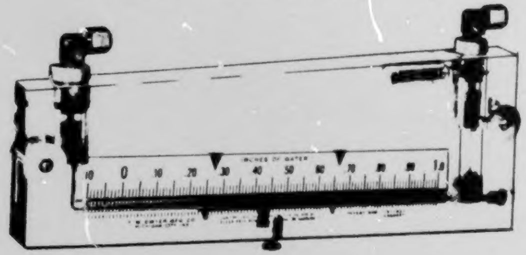


Aneometer


90
0
10
20
80
50

Air Meters

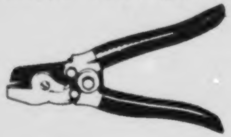
Incline Manometer


INCHES OF WATER
0
10
20
30
40
50
60
70
80
90
1.0

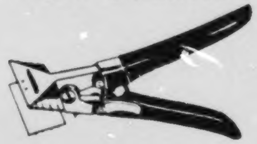
Special Tools

(Continued)

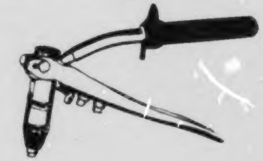
Hand Notcher



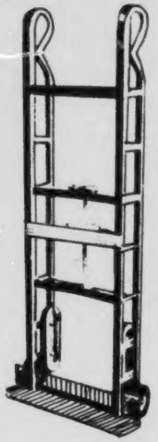
Hand Seamer



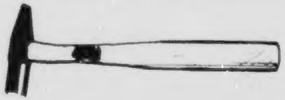
Riveter



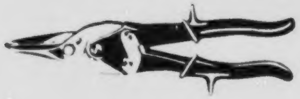
Appliance Truck



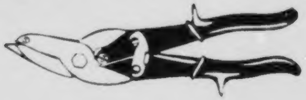
Riveting Hammer



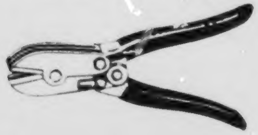
Aviation Snips



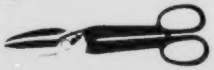
Double Cutting Snips



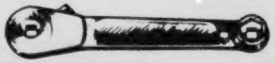
Hand Crimper



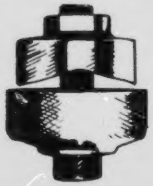
Combination Pattern Snips



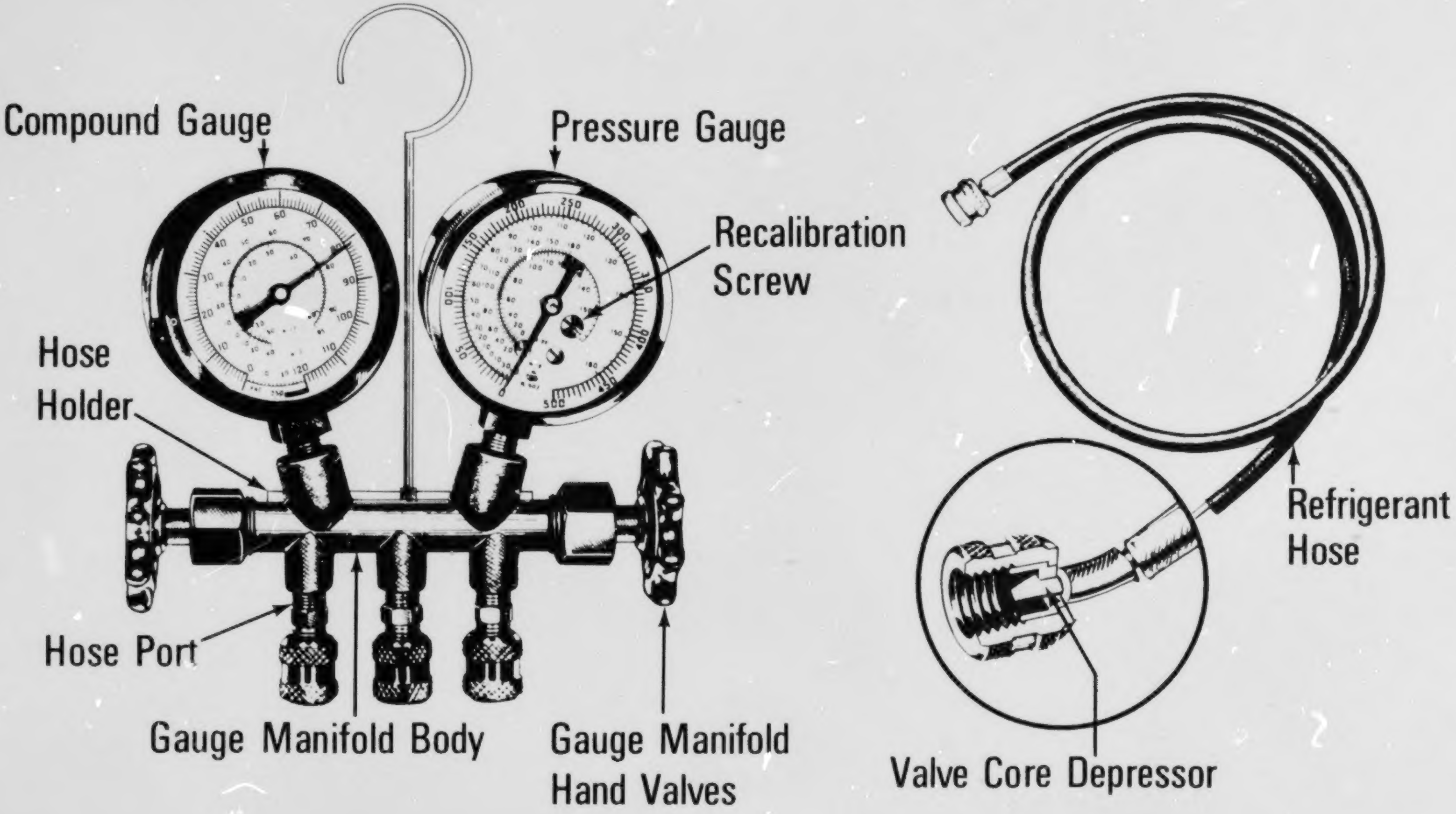
Refrigeration Ratchet



Knock-Out Cutter



Refrigeration Gauge Set Components


Compound Gauge
Pressure Gauge
Recalibration Screw
Hose Holder
Hose Port
Gauge Manifold Body
Gauge Manifold Hand Valves
Refrigerant Hose
Valve Core Depressor

TM - 9

ACR I - 105-C

SPECIAL TOOLS
UNIT II

JOB SHEET #1--SHARPEN A TWIST DRILL BIT

I. Tools and materials

  A. Drill bit

  B. Bench grinder

  C. Water tray

  D. Safety glasses

  E. Drill bit gauge

  F. Oil stone

II. Procedure

  A. Put on safety glasses

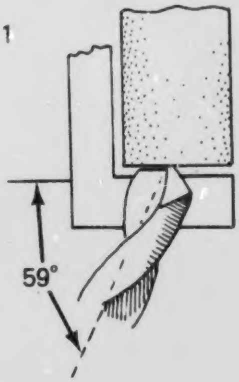
  B. Adjust tool rest to proper clearance

  (NOTE: Proper clearance is approximately one-eighth inch from wheel.)

  C. Turn on grinder

  D. Grind each lip of the drill bit to proper angle of 59° (Figure 1)

FIGURE 1

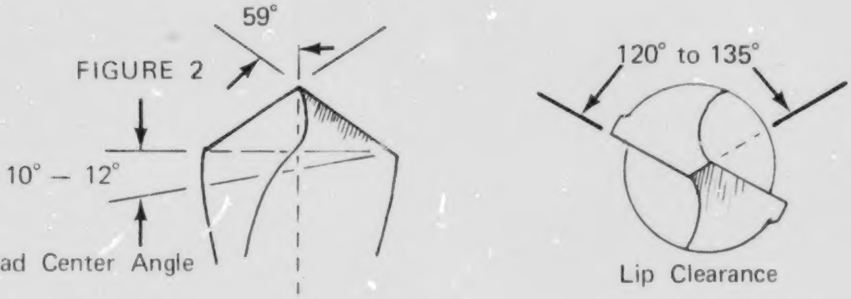


Grinding the Drill

JOB SHEET #1

E. Roll drill bit to the right and up to the face of the stone to generate back clearance angle of 10° to 12° (Figure 2)

FIGURE 2



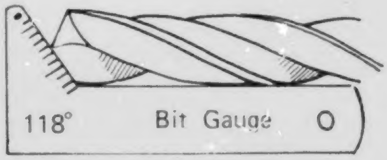
Dead Center Angle

Lip Clearance

F. Dip in water tray occasionally to prevent overheating the drill bit

G. Check correct angle with a bit gauge (Figure 3)

FIGURE 3



Check Angle

H. Turn off grinder

I. Hone cutting edges of the drill bit to remove burrs

J. Recheck all cutting angles

SPECIAL TOOLS
UNIT II

TEST

1. Match the terms on the right to the correct definitions.

_____a. Humidity sensing device

_____b. Instrument consisting of a "U" shaped glass tube with either mercury or water in it for the measurement of pressure gases

_____c. Tubular enclosure for electrical conductors

_____d. Replacing or adding refrigerant to a refrigeration system

_____e. Vacuum of 2000 to .1 microns and requires a two stage pump; also called a deep vacuum

_____f. Using a vacuum pump to pull a vacuum on a refrigeration system for the purpose of removing air and moisture

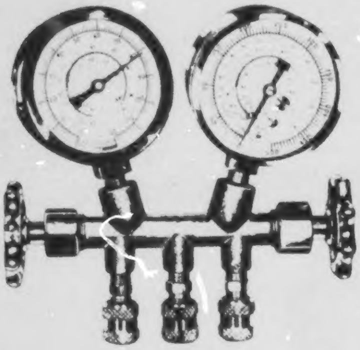
_____g. Sealed system

_____h. Burning of fuels

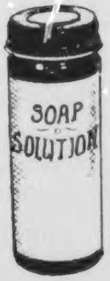
_____i. Lead made up of two dissimilar metals which creates a small amount of voltage upon temperature change

1. Hygrometer
2. High vacuum
3. Conduit
4. Evacuating
5. Charging
6. Thermal electric lead
7. Manometer
8. Hermetic
9. Combustion

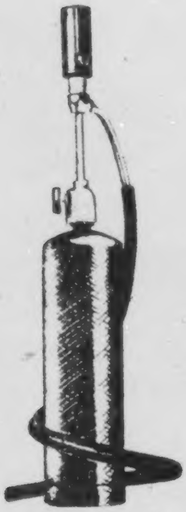
2. Identify specialized tools.



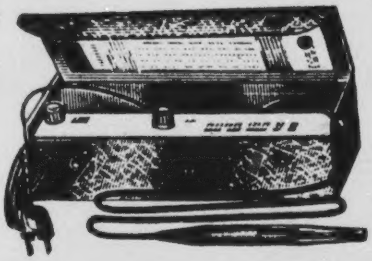
a. ______________________


SOAP
SOLUTION

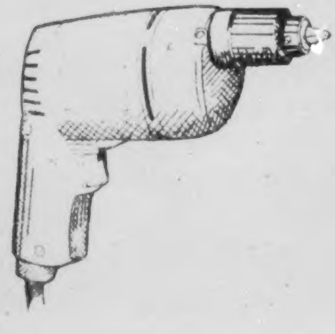
b. ______________________



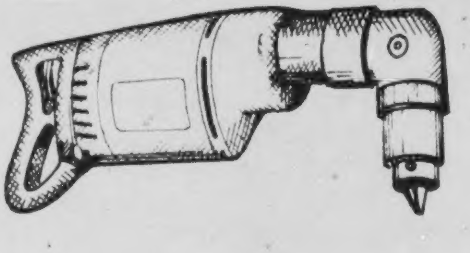
c. ______________________



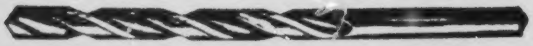
d. ______________________



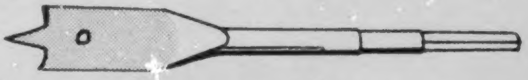
e. ______________________



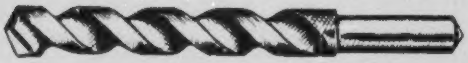
f. ______________________



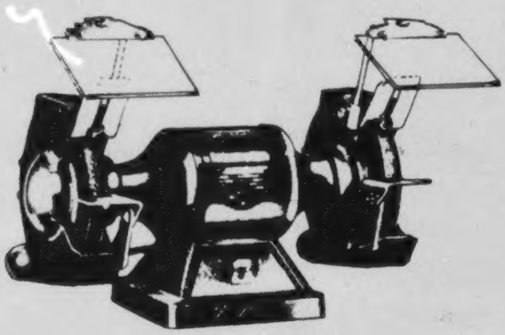
g. ______________________________



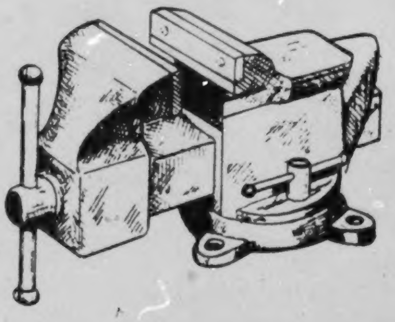
h. ______________________________



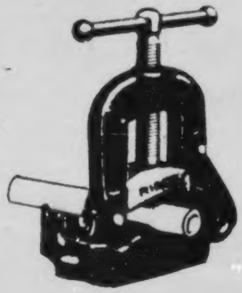
i. ______________________________



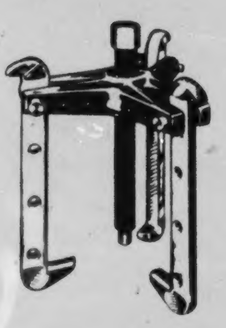
j. ______________________________



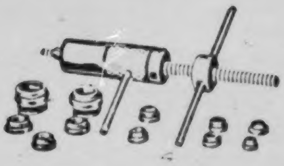
k. ______________________________



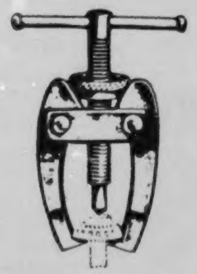
l. ______________________________



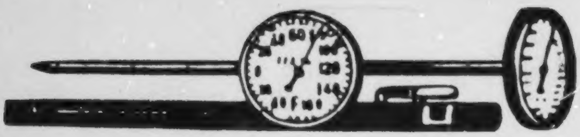
m. ______________________________



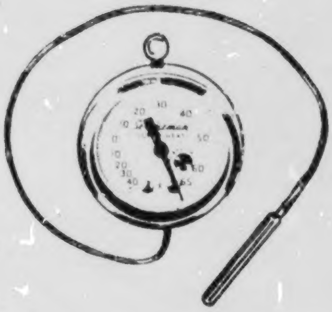
n. ______________________________



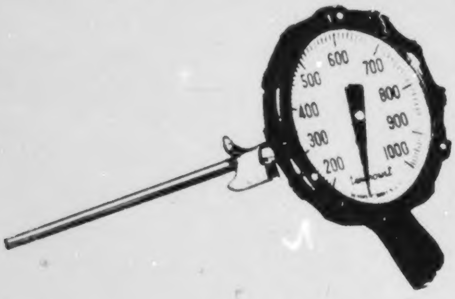
o. ______________________________



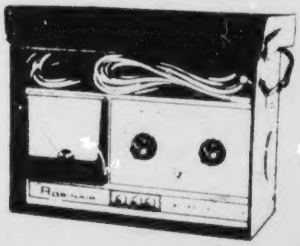
p. ____________________



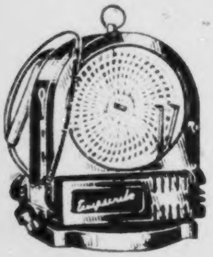
q. ____________________


200
300
400
500
600
700
800
900
1000

r. ____________________



s. ____________________



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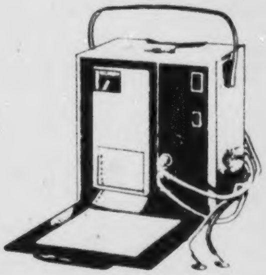
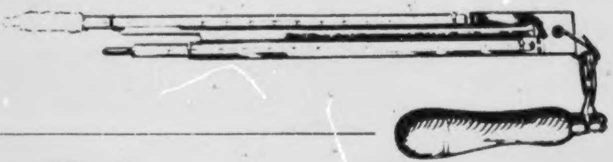
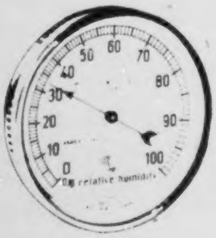


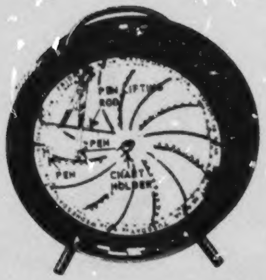
u. ____________________



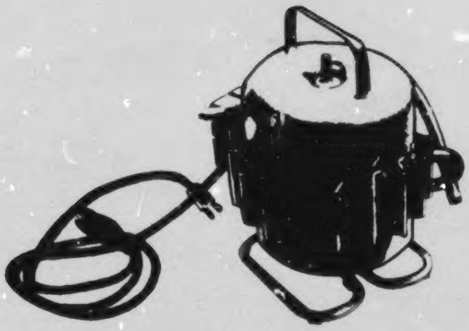
v. ____________________


0
10
20
30
40
50
60
70
80
90
100
% relative humidity

w. ____________________


PEN LIFTING ROD
PEN
PEN
CHART HOLDER

x. ________________________



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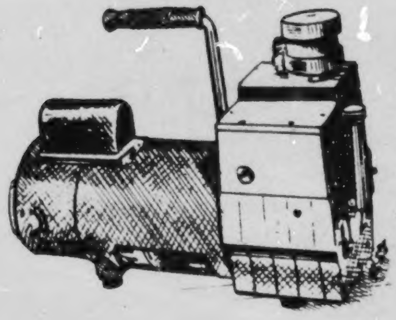
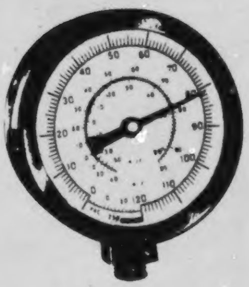


z. ________________________



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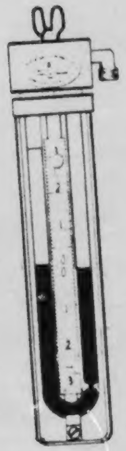
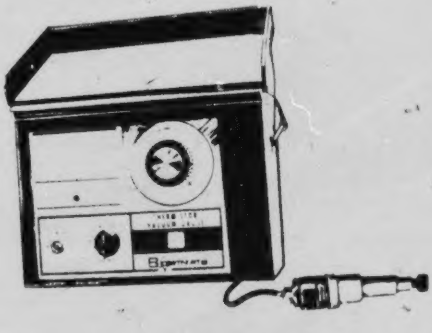
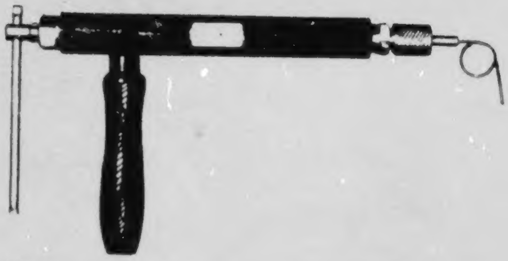


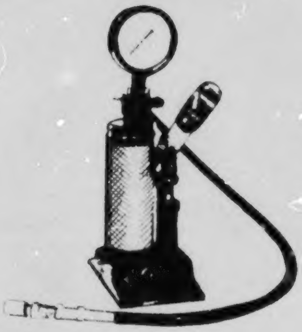
bb. ________________________



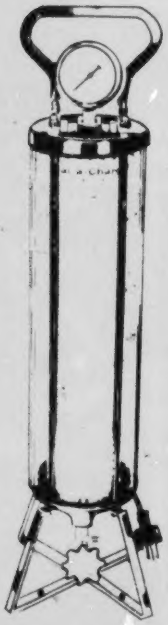
cc. ________________________



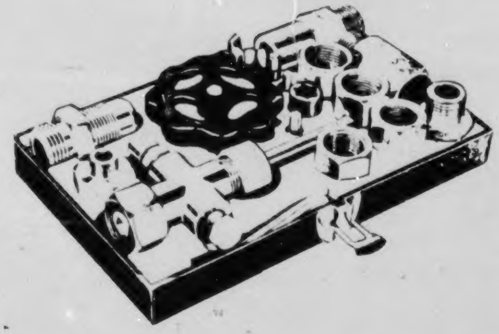
dd. ____________________



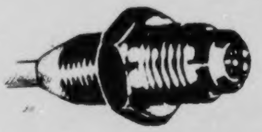
ee. ____________________



ff. ____________________



gg. ____________________



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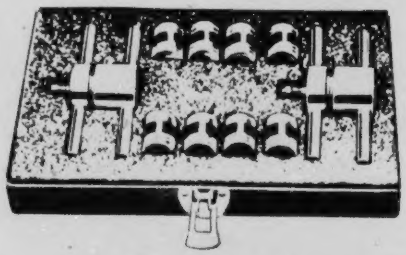

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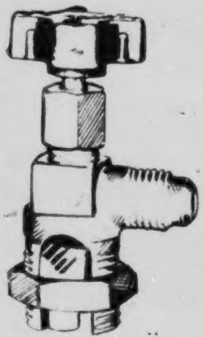

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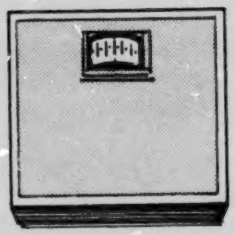

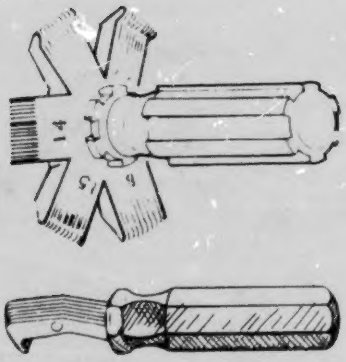

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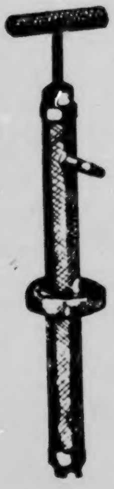

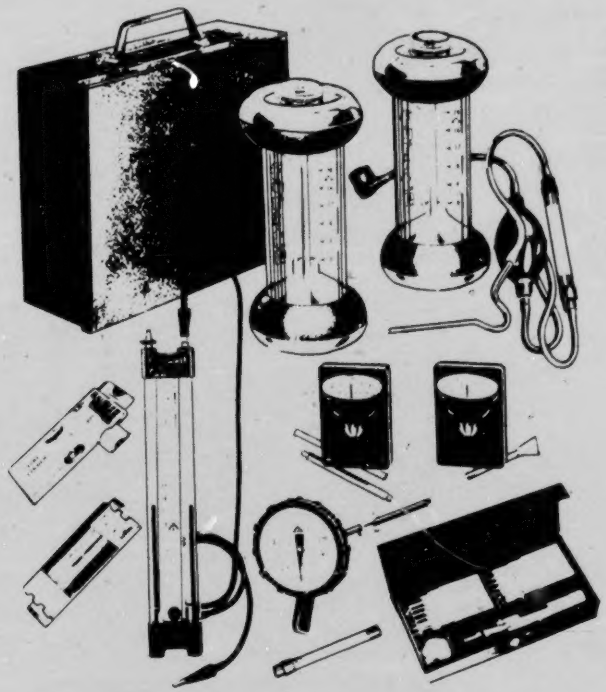

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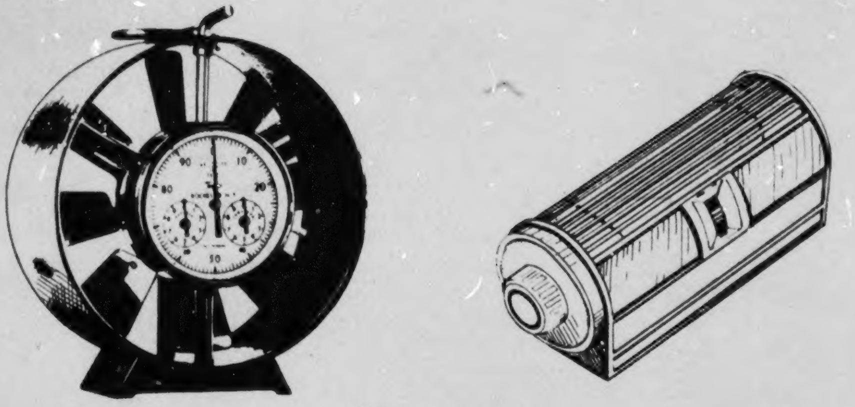

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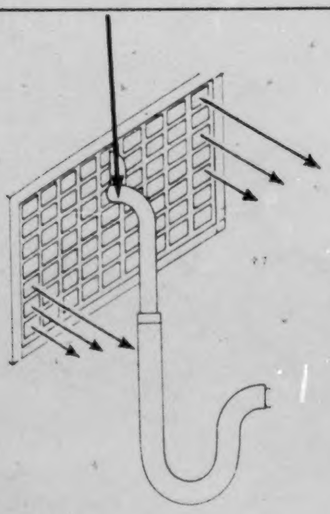

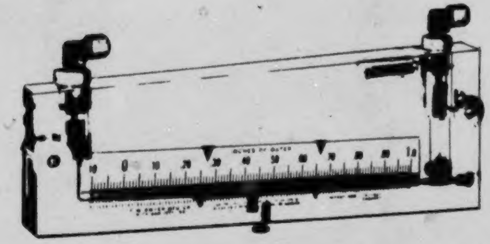

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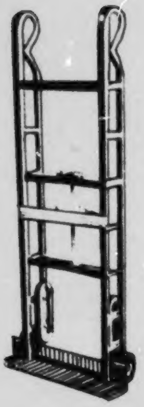

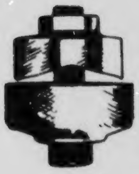

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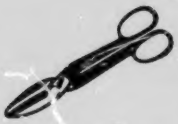

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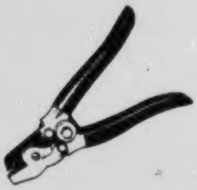

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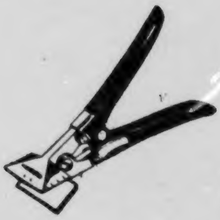

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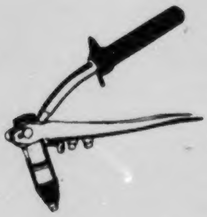

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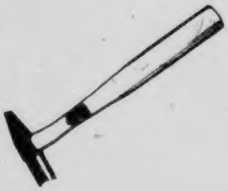

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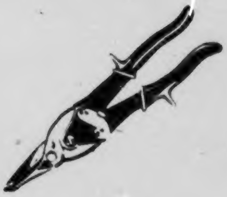

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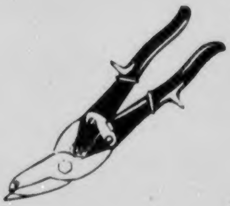

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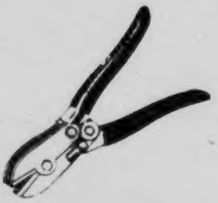

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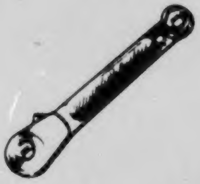


bbb. ____________________

3. Describe the use of the specialized tools.
   - a. Thermometers
      - 1) Flue and stack--
      - 2) Thermal electric--
      - 3) Pocket--
      - 4) Remote bulb--
   - b. Leak detectors--
   - c. Vacuum pumps
      - 1) High vacuum--
      - 2) Low vacuum--
   - d. Capillary tube cleaners
      - 1) Manual--
      - 2) Hydraulic--
   - e. Oil pump--
   - f. Service valves
      - 1) Access core type valves--
      - 2) Process tube adapters--
      - 3) Hermetic service valve kit--
      - 4) Line piercing valves--

g. Pullers
    1) Gear--
    2) Bearing--
    3) Wheel--

h. Scales--

i. Combination pattern snips--

j. Refrigeration ratchet--

k. Refrigeration gauge set--

l. Vises
    1) Pipe--
    2) Bench--
m. Hand notcher--
n. Drill motors
    1) Straight--
    2) Offset--
o. Recording thermometers
    1) Manual wind--
    2) Electric--
p. Bench grinders--
q. Vacuum indicators
    1) Mercury manometer--

   2) Compound gauge--

   3) Thermocouple micron gauge--

r. Hand crimper--

s. Drill bits

   1) Twist--

   2) Wood--

   3) Masonry--

t. Aviation snips

   1) Right-hand--

   2) Left-hand--

u. Knock-out cutter--

v. Hygrometers

   1) Sling psychrometer--

   2) Dial type--

   3) Humidity recorder--

w. Combustion testing kit--

x. Charging cylinder--

y. Fin combs--

z. Double cutting snips--

aa. Air meters

1) Incline manometer--

2) Pitot tube--

3) Aneometer--

bb. Riveting hammer--

cc. Riveter--

dd. Appliance truck--

ee. Hand seamer--

4. Describe the care of the specialized tools.

a. Thermometers

b. Leak detectors

c. Vacuum pumps

d. Capillary tube cleaners

e. Oil pump

f. Service valves

g. Pullers

h. Scales

i. Combination pattern snips

j. Refrigeration ratchet

k. Refrigeration gauge set

l. Vises

m. Hand notcher

n. Drill motors

o. Recording thermometers

p. Bench grinders

q. Vacuum indicators

r. Hand crimper

s. Drill bits

t. Aviation snips

u. Knock-out cutter

v. Hygrometers

w. Combustion testing kit

x. Charging cylinders

y. Fin combs

z. Double cutting snips

aa. Air meters

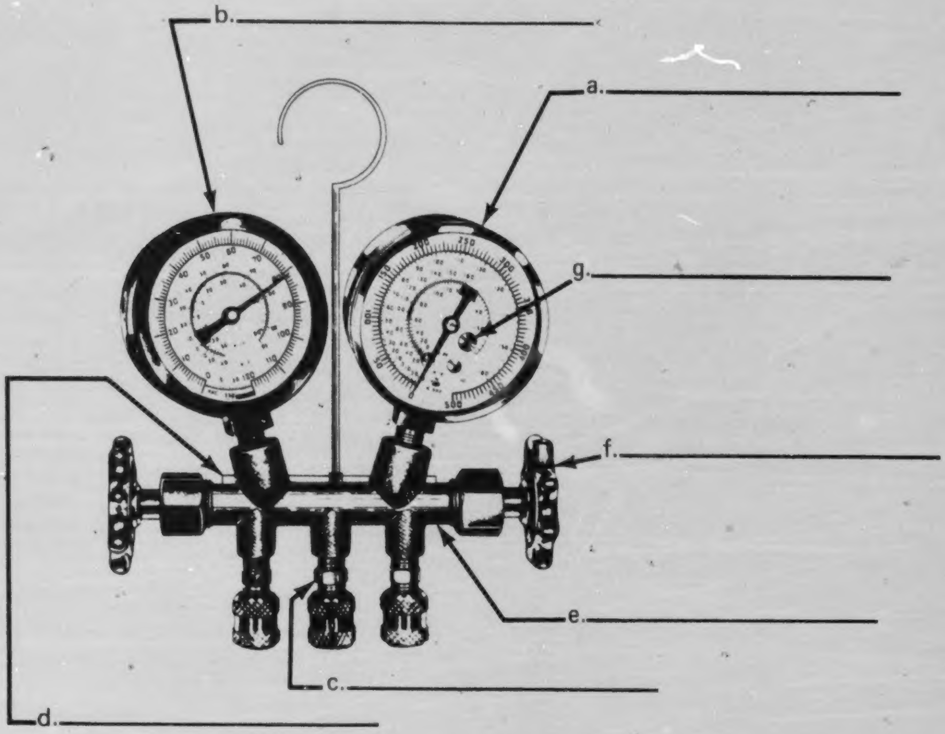
bb. Riveting hammer

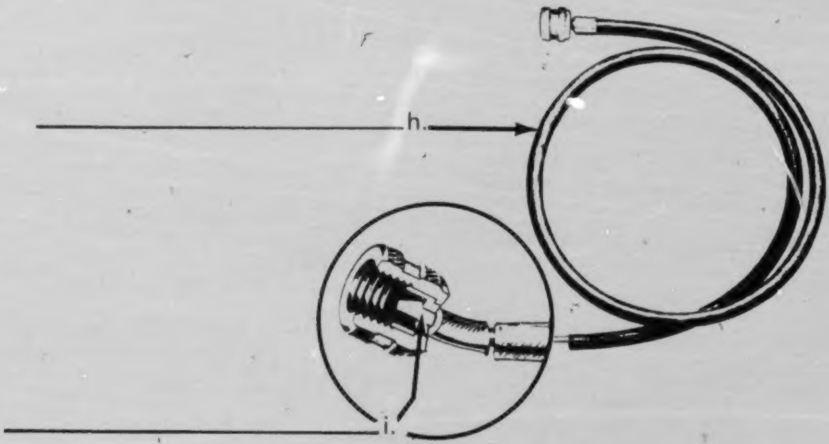
cc. Riveter

dd. Appliance truck

ee. Hand seamer

5. Identify the components of the refrigeration gauge set.





6. List when each refrigeration gauge set component is used.
   a. Gauge manifold
      1)
      2)
      3)
   b. Compound gauge
      1)
      2)
      3)
      4)
   c. Pressure gauge
      1)
      2)
      3)
      4)
   d. Refrigerant hoses
      1)
      2)
      3)
      4)
   e. Hose holder
      1)
      2)
7. Demonstrate the ability to sharpen a twist drill bit.

(NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

SPECIAL TOOLS
UNIT II

ANSWERS TO TEST

1. a. 1
   b. 7
   c. 3
   d. 5
   e. 2
   f. 4
   g. 8
   h. 9
   i. 6

2. a. Refrigeration gauge set
   b. Soap solution leak detector
   c. Halide torch leak detector
   d. Electronic leak detector
   e. Straight drill motor
   f. Offset drill motor
   g. Twist drill bit
   h. Wood drill bit
   i. Masonry drill bit
   j. Bench grinder
   k. Bench vise
   l. Pipe vise
   m. Wheel puller
   n. Bearing puller
   o. Gear puller
   p. Pocket thermometer
   q. Remote bulb thermometer
   r. Flue and stack thermometer

s. Thermal electric thermometer
t. Manual wind recording thermometer
u. Electric recording thermometer
v. Sling psychrometer
w. Dial type hygrometer
x. Humidity recorder
y. Low vacuum pump
z. High vacuum pump
aa. Compound gauge
bb. Mercury manometer
cc. Thermocouple micron gauge
dd. Manual capillary tube cleaner
ee. Hydraulic capillary tube cleaner
ff. Charging cylinder
gg. Hermetic service valve kit
hh. Access core type valves
ii. Process tube adapters
jj. Line piercing valves
kk. Scales
ll. Fin comb
mm. Oil pump
nn. Combustion testing kit
oo. Aneometer
pp. Pitot tube
qq. Incline manometer
rr. Appliance truck.

ss. Knock-out cutter
tt. Combination pattern snips
uu. Hand notcher
vv. Hand seamer
ww. Riveter
xx. Riveting hammer
yy. Aviation snips
zz. Double cutting snips
aaa. Hand crimper
bbb. Refrigeration ratchet

3. Description should include:

   a. Thermometers

      1) Flue and stack--For checking the temperatures created in gas flues and stacks

      2) Thermal electric--For measuring temperatures from -50° to as high as +1000°F

      3) Pocket--For checking the temperature of refrigeration components and systems

      4) Remote bulb--For checking temperatures in one area and reading the temperature on a dial in another area

   b. Leak detectors--For locating refrigerant leaks

   c. Vacuum pumps

      1) High vacuum--For evacuating a refrigeration system; used in conjunction with a high vacuum gauge manifold and micron gauge

      2) Low vacuum--For evacuating a refrigeration system; used in conjunction with a gauge manifold

   d. Capillary tube cleaners

      1) Manual--Forces oil or R-11 through a capillary tube when the pressure handle is turned clockwise

      2) Hydraulic--Forces oil or R-11 through a capillary tube with the use of a hydraulic pump

e. Oil pump--For putting oil into a compressor without the danger of contamination

f. Service valves

   1) Access core type valves--Allow the refrigerant system pressures to be checked when the gauge hose depresses the core

   2) Process tube adapters--Provides a gauge connection by fitting onto the end of charging stubs

   3) Hermetic service valve kit--Allows the connection of refrigeration gauges to some hermetic systems

   4) Line piercing valves--Allow a gauge connection by tightening onto a charging stub and piercing it

g. Pullers

   1) Gear--For removing small pulleys or gears from motor shafts

   2) Bearing--For removing or installing bearings and bushings in motors

   3) Wheel--For removing pulleys and bearings from motor shafts

h. Scales--For weighing the amount of refrigerant during the charging process

i. Combination pattern snips--For all general purpose cutting of sheet metal

j. Refrigeration ratchet--For front seating and back seating service valves and acetylene cylinder valves

k. Refrigeration gauge set--For charging, evacuating, and checking pressures on refrigeration systems

l. Vises

   1) Pipe--For holding pipe or conduit secure

   2) Bench--For holding objects secure

m. Hand notcher--For cutting notches in the edge of sheet metal

n. Drill motors

   1) Straight--For drilling holes in metal or wood

   2) Offset--For drilling holes in metal or wood in limited working space

o. Recording thermometers

   1) Manual wind--Records temperatures on a time chart

   2) Electric--Records temperatures on a strip chart

p. Bench grinders--For grinding metal edges

q. Vacuum indicators

   1) Mercury manometer--Indicates an accurate vacuum reading below 25 inches; used with a vacuum pump

   2) Compound gauge--Indicates vacuum accurately to 25 inches of mercury

   3) Thermocouple micron gauge--An extremely accurate vacuum indicator; used in conjunction with a high vacuum pump

r. Hand crimper--For crimping the end of sheet metal pipe so that sections may be fitted together

s. Drill bits

   1) Twist--For drilling metal

   2) Wood--For drilling wood

   3) Masonry--For drilling concrete and stone

t. Aviation snips

   1) Right-hand--For cutting sheet metal in a right-handed direction

   2) Left-hand--For cutting sheet metal in a left-handed direction

u. Knock-out cutter--For making holes in sheet metal

v. Hygrometers

   1) Sling psychrometer--Wet-bulb and dry-bulb temperature will be obtained by whirling the psychrometer for 15 to 20 seconds

   2) Dial type--Contains human hair that reacts to humidity changes which gives a meter reading

   3) Humidity recorder--Records humidity changes on a time chart

w. Combustion testing kit--For servicing gas or oil furnaces to detect CO_2 content, draft, stack temperature, and smoke

x. Charging cylinder--For charging the proper amount of refrigerant into a system; used with a gauge manifold set

y. Fin combs--For straightening the heat transfer fins on condensers and evaporators

z. Double cutting snips--For cutting sheet metal where both pieces of metal must lay flat

aa. Air meters

  1) Incline manometer--Used with a pitot tube to determine air velocity pressure and static pressure

  2) Pitot tube--Determines air speed by obtaining air pressure through a grille

  3) Aneometer--Measure the speed of the air being supplied through a grille

bb. Riveting hammer--For forming the sheet metal

cc. Riveter--For riveting pieces of sheet metal together

dd. Appliance truck--For moving refrigerators and other heavy equipment

ee. Hand seamer--For forming a seam on a piece of sheet metal, by hand

4. Description should include:

a. Thermometers

  1) Do not drop

  2) Do not kink remote bulb capillaries

  3) Use only in proper temperature range

  4) Keep pocket thermometers in case when not in use

  5) Check batteries on thermal electric

b. Leak detectors

  1) Clean orifice and hose of halide torch

  2) Electronic leak detectors

    a) Do not drop

    b) Keep probe clean

    c) Do not use around a heavy concentration of refrigerant

c. Vacuum pumps

    1) Change oil often

    2) Keep clean

d. Capillary tube cleaners

    1) Keep clean

    2) Do not overpressurize gauge on hydraulic pump type

e. Oil pump

    1) Keep clean

    2) Put away when not in use

    3) Always replace cap to prevent oil contamination

f. Service valves

    1) Do not overtighten hermetic service valves

    2) Do not overtighten valve cores

    3) Remove line piercing valves after system servicing is over

g. Pullers

    1) Keep tip pointed

    2) Oil threaded shaft

    3) Do not drop

h. Scales

    1) Do not try to weigh objects heavier than the limits of the scales

    2) Do not try to weigh objects with the scale dial in the locked position

i. Combination pattern snips

    1) Do not throw or drop

    2) Keep sharp

    3) Oil swivel point

j. Refrigeration ratchet
    1) Do not apply excessive force on ratchet mechanism
    2) Oil
    3) Do not use as a hammer

k. Refrigeration gauge set
    1) Keep hoses plugged
    2) Check gauge calibration
    3) Oil manifold hand valve stems twice a year
    4) Replace gauge lenses if cracked or broken

l. Vises
    1) Keep clean
    2) Oil clamping screw
    3) Do not hammer on jaws
    4) Do not overtighten

m. Hand notcher
    1) Use only on proper gauge metal
    2) Oil
    3) Do not throw or drop

n. Drill motors
    1) Check for defective cord
    2) Do not overload
    3) Keep motor cooling openings clear
    4) Do not drop
    5) Do not lift by cord

o. Recording thermometers
    1) Do not drop

2) Do not wind clock too tight on manual wind

3) Place recorder where it will not be knocked off

p. Bench grinders

1) Keep safety shield clean and in place

2) Keep tool rest tight

3) Tell instructor when grinding wheel needs to be dressed

q. Vacuum indicators

1) Do not drop

2) Keep clean

3) Store in safe place when not in use

r. Hand crimper

1) Do not throw or drop

2) Keep oiled and clean

s. Drill bits

1) Keep sharp

2) Do not force or bend

3) Use a few drops of cutting oil when drilling heavy metal

4) Do not use wood bits for sheet metal

5) Use water as a coolant when drilling concrete or stone

t. Aviation snips

1) Do not throw or drop

2) Keep sharp

3) Keep oiled and clean

u. Knock-out cutter

1) Do not drop

2) Use only on proper gauge metal

v. Hygrometers

  1) Do not drop

  2) Use distilled water on wet-bulb wick

  3) Keep in case when not in use

  4) Change wick frequently

w. Combustion testing kit

  1) Read instructions included in kit

  2) Store in a safe place when not in use

x. Charging cylinders

  1) Keep clean

  2) Do not drop or knock over

  3) If refrigerant is left in cylinder, tag it as to type of refrigerant

  4) Do not heat with a torch

y. Fin combs--Do not drop

z. Double cutting snips

  1) Do not throw or drop

  2) Keep sharp

  3) Keep oiled and clean

aa. Air meters

  1) Do not drop

  2) Store in a safe place when not in use

bb. Riveting hammer

  1) Do not throw or drop

  2) Keep handle tight

cc. Riveter

  1) Keep clean and oiled

  2) Do not throw or drop

dd. Appliance truck
  1) Lubricate wheel bearings
  2) Roll strap up on ratchet when not being used
  3) Oil ratchet mechanism every three months
  4) Move only objects the truck can support

ee. Hand seamer
  1) Keep clean and oiled
  2) Do not throw or drop

5. a. Pressure gauge
   b. Compound gauge
   c. Hose port
   d. Hose holder
   e. Gauge manifold body
   f. Gauge manifold hand valves
   g. Recalibration screw
   h. Refrigerant hose
   i. Valve core depressor

6. a. Gauge manifold
     1) Charging
     2) Evacuating
     3) Checking pressures
   b. Compound gauge
     1) Charging vapor
     2) Evacuating
     3) Pressurizing
     4) Checking low side pressures

c. Pressure gauge

    1) Charging into high side

    2) Evacuating through both sides

    3) Pressurizing

    4) Checking high side pressures

d. Refrigerant hoses

    1 Charging

    2) Evacuating

    3) Pressurizing

    4) Checking pressures

e. Hose holder

    1) Keeping hoses clean

    2) Holding hoses when not in use

7. Performance skill evaluated to the satisfaction of the instructor

MEASURING
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify, care for, read, and use the types of measuring instruments used in the air-conditioning and refrigeration trade. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with measuring instruments to the correct definitions.
2. Identify measuring instruments.
3. Read the sixteenth's rule.
4. List guidelines for the use and care of rules and steel tapes.
5. List the procedures for the use of the drill and wire gauges.
6. Identify the major parts of calipers.
7. List rules for use and care of calipers.
8. Identify the major parts of micrometers.
9. List seven rules for the care of micrometers.
10. Read a micrometer.
11. Demonstrate the ability to:
    a. Measure lines to the nearest quarter, eighth, and sixteenth of an inch.
    b. Read a rule.
    c. Measure inside and outside diameters.
    d. Read the circumference rule.

e. Use the inside and outside calipers.

f. Read the micrometer settings.

g. Use the outside micrometer.

h. Use the inside micrometer.

MEASURING
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information, assignment, and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Invite outside speakers such as a machinist or the machine shop instructor.

   H. Have a speed contest between students on making accurate measurements.

   I. Build a large rule to hang up in front of classroom.

   J. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment and job sheets.

   D. Complete activities assigned by instructor.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

C. Transparency masters

1. TM 1--Measuring Instruments
2. TM 2--Measuring Instruments (Continued)
3. TM 3--Graduations on a Rule
4. TM 4--Reading the Eighth's Rule
5. TM 5--Reading the Sixteenth's Rule
6. TM 6--Major Parts of Calipers
7. TM 7--Uses of Inside and Outside Calipers
8. TM 8--Parts of the Outside Micrometer
9. TM 9--Parts of the Inside Micrometer
10. TM 10--Uses of the Inside Micrometer
11. TM 11--Reading a Micrometer
12. TM 12--Sleeve Readings

    Overlay A--Thimble

D. Assignment sheets

1. Assignment Sheet #1--Measure Lines to the Nearest Quarter, Eighth, and Sixteenth of an Inch
2. Assignment Sheet #2--Read a Rule
3. Assignment Sheet #3--Measure Inside and Outside Diameters
4. Assignment Sheet #4--Read the Circumference Rule
5. Assignment Sheet #5--Use the Inside and Outside Calipers
6. Assignment Sheet #6--Read the Micrometer Settings

E. Answers to assignment sheets

F. Job sheets

1. Job Sheet #1--Use the Outside Micrometer
2. Job Sheet #2--Use the Inside Micrometer

G. Test

H. Answers to test

II. References:

A. *Machine Shop Curriculum.* Stillwater, Oklahoma: Curriculum and Instructional Materials Center / State Department of Vocational and Technical Education, 1972.

B. Zinngrabe, Claude J. *Sheet Metal Blueprint Reading for the Building Trades.* Albany, New York: Delmar Publishers, 1971.

MEASURING
UNIT III

INFORMATION SHEET

I. Terms and definitions

  A. Measure--Setting of limits or bounds according to a predetermined standard

  B. Foot--Unit of measure consisting of twelve equal parts called inches

  C. Rule--Measuring instrument that is divided into feet, inches, and fractions of inches

  D. Diameter--Length of a straight line through the center of a circular object

  E. Circumference--Distance around a circle

II. Measuring instruments (Transparency 1)

  A. Rules

    1. Combination square
    2. Folding rule
    3. Steel rule
    4. Circumference rule
    5. Steel tape

  B. Gauges (Transparency 2)

    1. Drill
    2. Wire

  C. Calipers (Transparency 2)

    1. Slide
    2. Outside
    3. Inside

INFORMATION SHEET

D. Micrometers (Transparency 2)

1. Outside
2. Inside

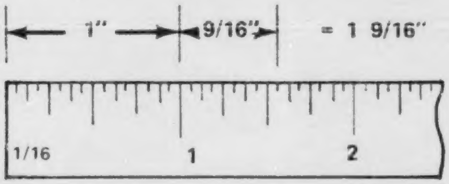
III. Reading a rule (Transparencies 3, 4, and 5)

A. All rules read similarly

(NOTE: Some rules are graduated with more divisions per inch than others.)

B. Procedure for reading

1. Count the divisions in one inch
2. Determine inches and divisions
   a. Count the graduations after the last full inch



   b. Add fractions to the last full inch
3. Reduce the fraction if possible
4. Determine the feet and add the inches and fraction of an inch to obtain a correct measurement

IV. Guidelines for the use and care of rules and steel tapes

A. Use the proper length and graduation

B. Use finest graduation for accuracy

C. Use a good quality rule

D. Never bend or distort a steel rule

E. Use only for intended purpose

F. Rewind steel tapes slowly

INFORMATION SHEET

G. Start measurement at one inch graduation for accuracy

H. Use rule on edge for accurate reading

I. Use lower edge of circumference rule for figuring circumferences only

V. Procedure for the use of drill and wire gauges

A. Drill gauge

1. Locate hole which drill bit fits

2. Read drill bit size

B. Wire gauge

1. Measuring metal thickness

a. Slide slot over sheet metal

b. Read thickness of metal

2. Measuring wire circumference

a. Insert wire into round opening

b. Read wire size

(NOTE: A wire gauge is only accurate for solid conductor wire.)

VI. Major parts of calipers (Transparency 6)

A. Slide caliper

1. Scale

2. Fixed jaw

3. Movable jaw

4. Clamping screw

B. Outside and inside calipers

1. Spring

2. Adjusting nut

3. Leg

INFORMATION SHEET

VII. Rules for use and care of calipers

   A. Use of calipers (Transparency 7)

      1. Fit part to be measured between caliper jaws or legs to measure outside diameter

         (NOTE: Calipers measure both inside and outside diameters of small parts. These measurements will be referred to as i.d. and o.d.)

      2. Mark on movable jaw will indicate the diameter on the scale

      3. Use inside and outside calipers to transfer measurement to a scale or pattern

   B. Care of calipers

      1. Do not drop

      2. Keep clean

      3. Do not overtighten clamping screw or adjusting nut

VIII. Major parts of micrometers

   A. Outside micrometer (Transparency 8)

      1. Frame

      2. Anvil

      3. Spindle

      4. Lock nut

      5. Sleeve

      6. Thimble

      7. Ratchet stop

   B. Inside micrometer (Transparencies 9 and 10)

      1. Body

      2. Anvil

INFORMATION SHEET

3. Thimble
4. Handle
5. Rod
6. Lock screw

IX. Rules for the care of micrometers

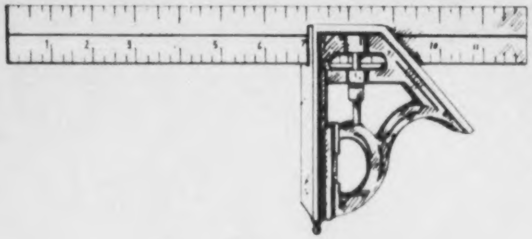
- A. Keep instrument away from heat, abrasive dust, moisture, oil, and grease
- B. Occasionally clean and lubricate instrument
- C. Check instrument for accuracy before use

  (NOTE: Observe for worn or loose parts.)
- D. Do not overtighten during measurement
- E. Properly store
- F. Handle instrument in correct manner
- G. Use instrument only for intended use

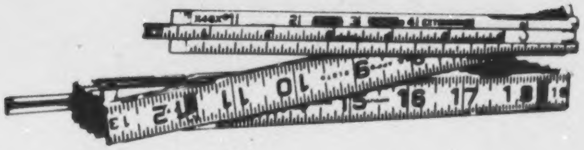
X. Reading a micrometer (Transparencies 11 and 12 and Overlay A)

- A. Each numbered graduation on the sleeve represents 0.100" (one-hundred thousandths of an inch)
- B. Each small graduation on the sleeve between the numbered graduations represents 0.025" (twenty-five thousandths of an inch)
- C. Each graduation found on the thimble represents 0.001" (one thousandth of an inch)
- D. Total the reading by adding the three values

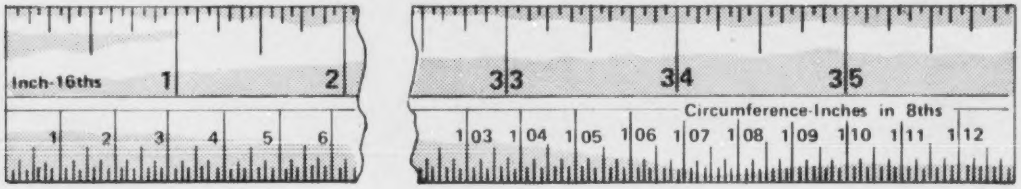
Measuring Instruments



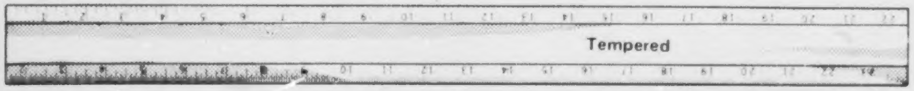
Combination Square



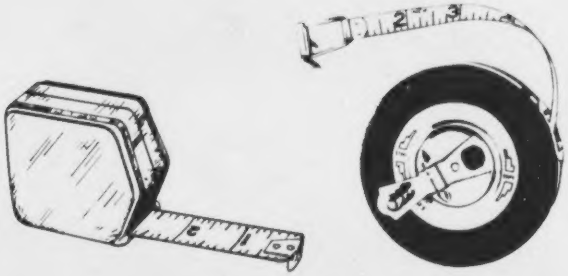
Folding Rule


Inch-16ths
1
2
33
34
35
Circumference-Inches in 8ths
1
2
3
4
5
6
103
104
105
106
107
108
109
110
111
112

Circumference Rule



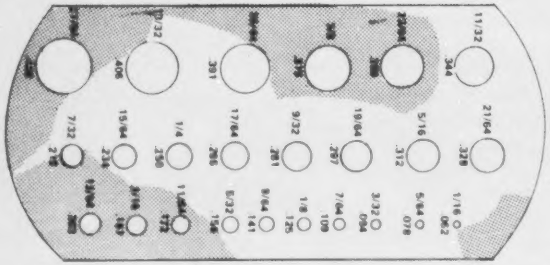
Steel Rule



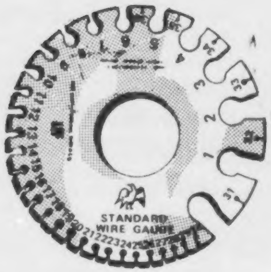
Steel Tapes

Measuring Instruments

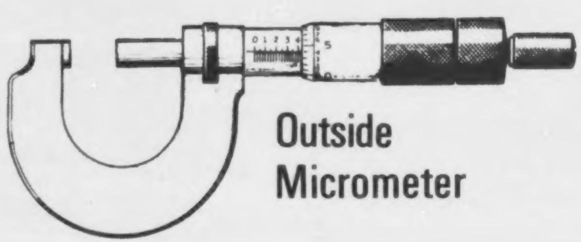
(Continued)



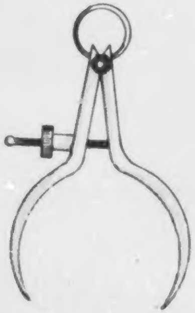
Drill Gauge


STANDARD
WIRE GAUGE

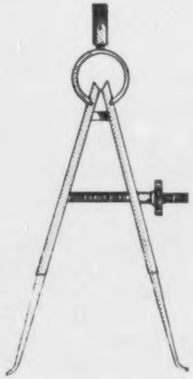
Wire Gauge



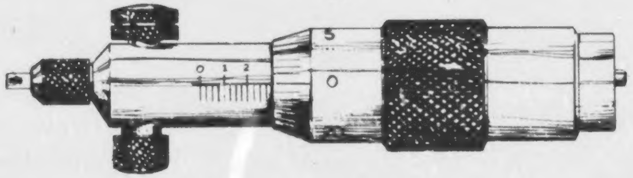
Outside Micrometer



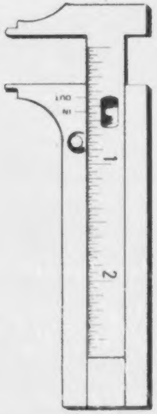
Outside Calipers



Inside Calipers



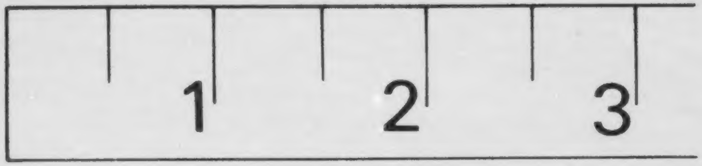
Inside Micrometer



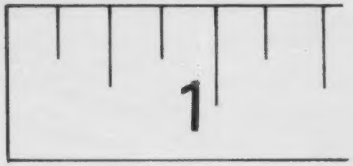
Slide Calipers

Graduations on a Rule

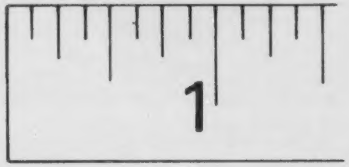
Halves



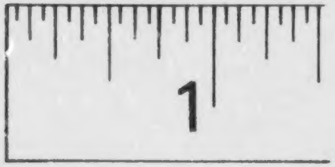
Quarters



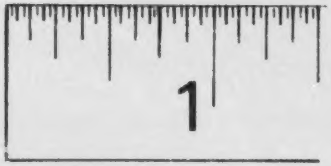
Eighths

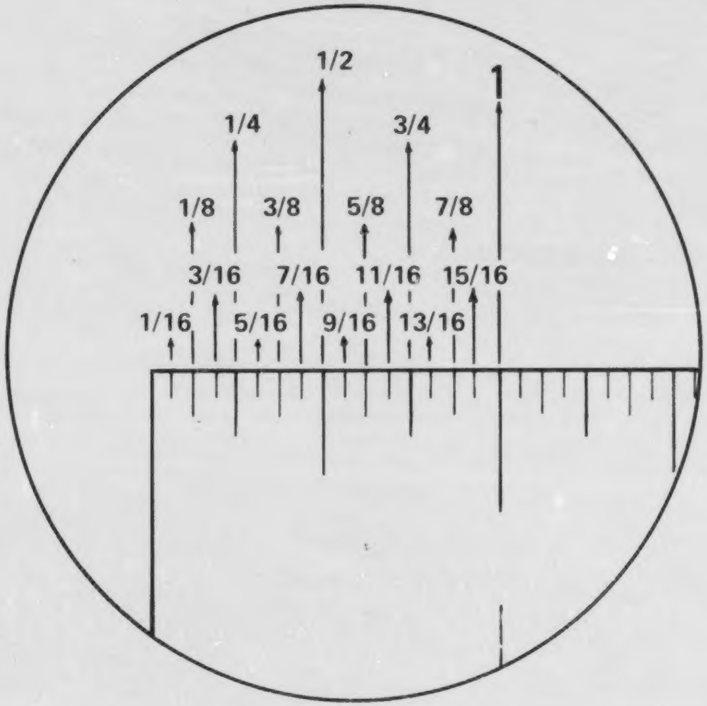


Sixteenths



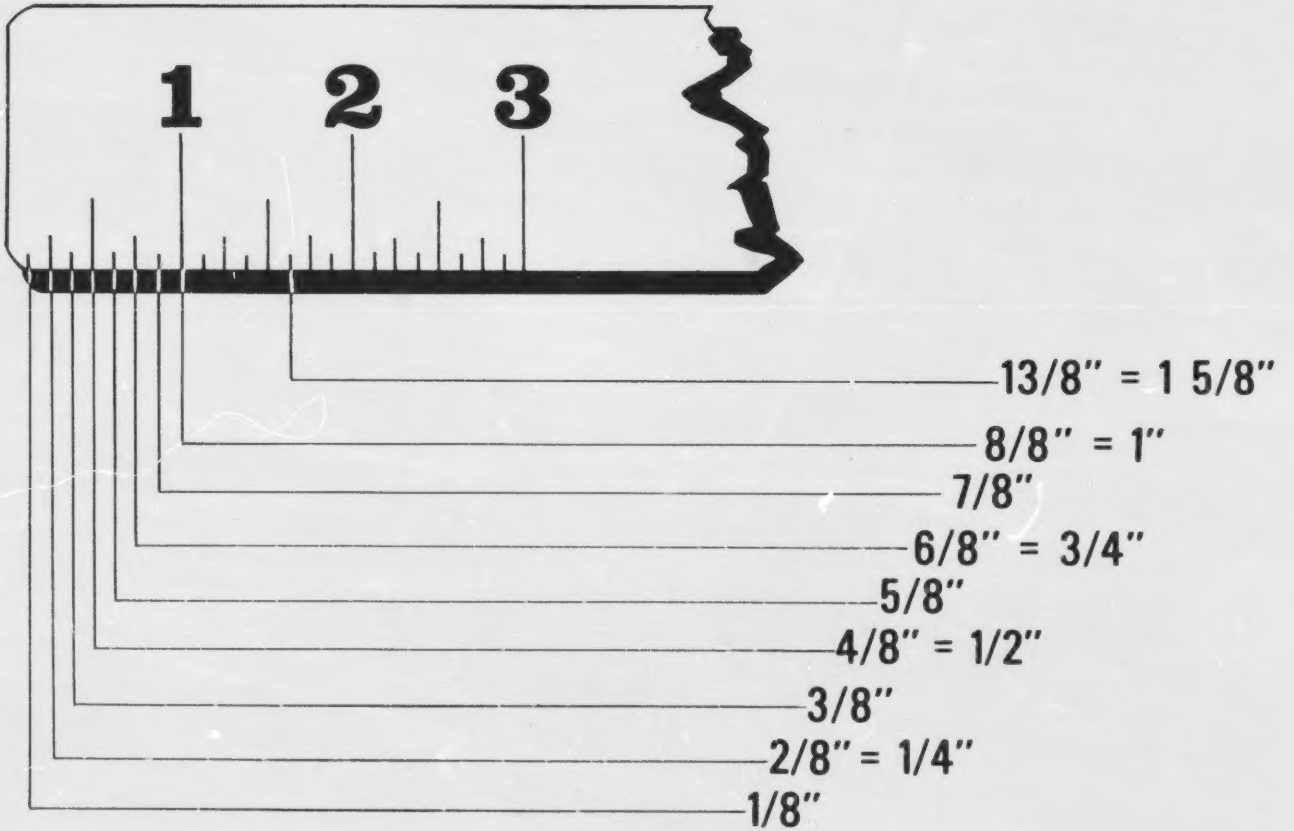
Thirty-Seconds



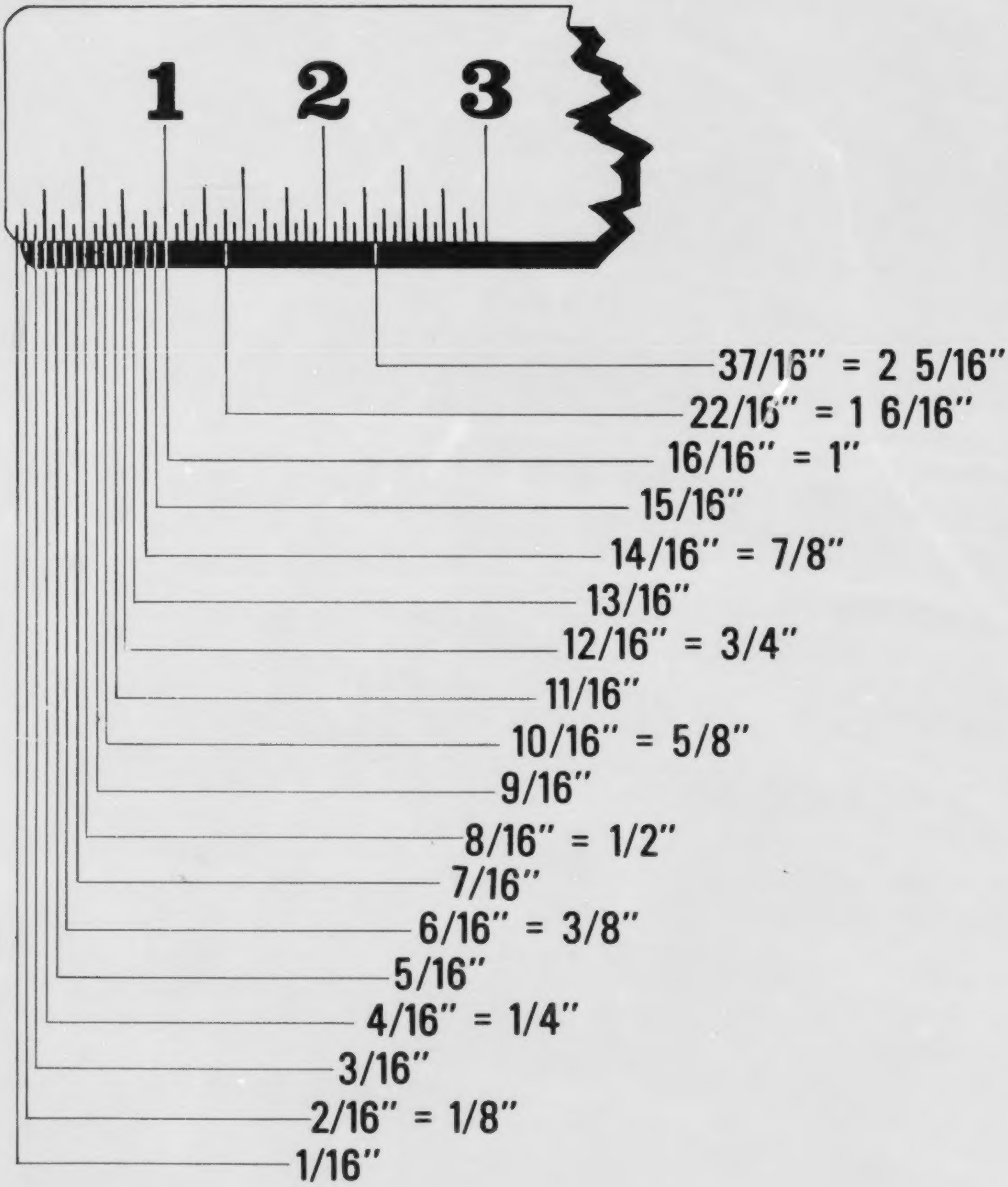

1/2
1
1/4
3/4
1/8
3/8
5/8
7/8
3/16
7/16
11/16
15/16
1/16
5/16
9/16
13/16

Graduations Applied to a Rule

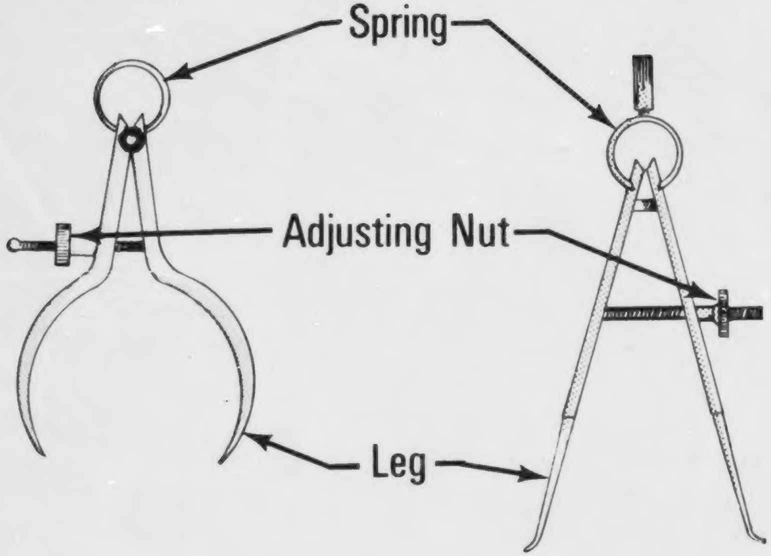
Reading the Eighths Rule


1
2
3
13/8" = 1 5/8"
8/8" = 1"
7/8"
6/8" = 3/4"
5/8"
4/8" = 1/2"
3/8"
2/8" = 1/4"
1/8"

Reading the Sixteenths Rule

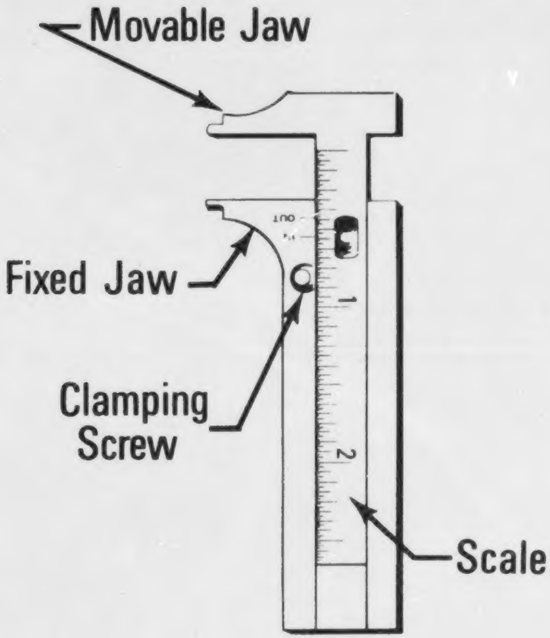

1
2
3
37/16" = 2 5/16"
22/16" = 1 6/16"
16/16" = 1"
15/16"
14/16" = 7/8"
13/16"
12/16" = 3/4"
11/16"
10/16" = 5/8"
9/16"
8/16" = 1/2"
7/16"
6/16" = 3/8"
5/16"
4/16" = 1/4"
3/16"
2/16" = 1/8"
1/16"

Major Parts of Calipers


Spring
Adjusting Nut
Leg

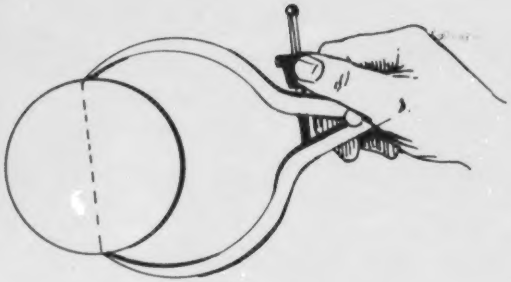
Outside Calipers

Inside Calipers

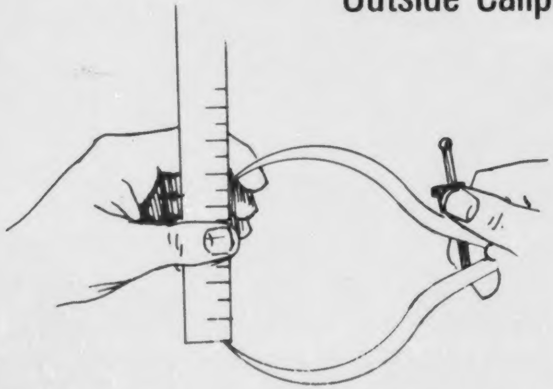

Movable Jaw
Fixed Jaw
Clamping Screw
Scale
1
2

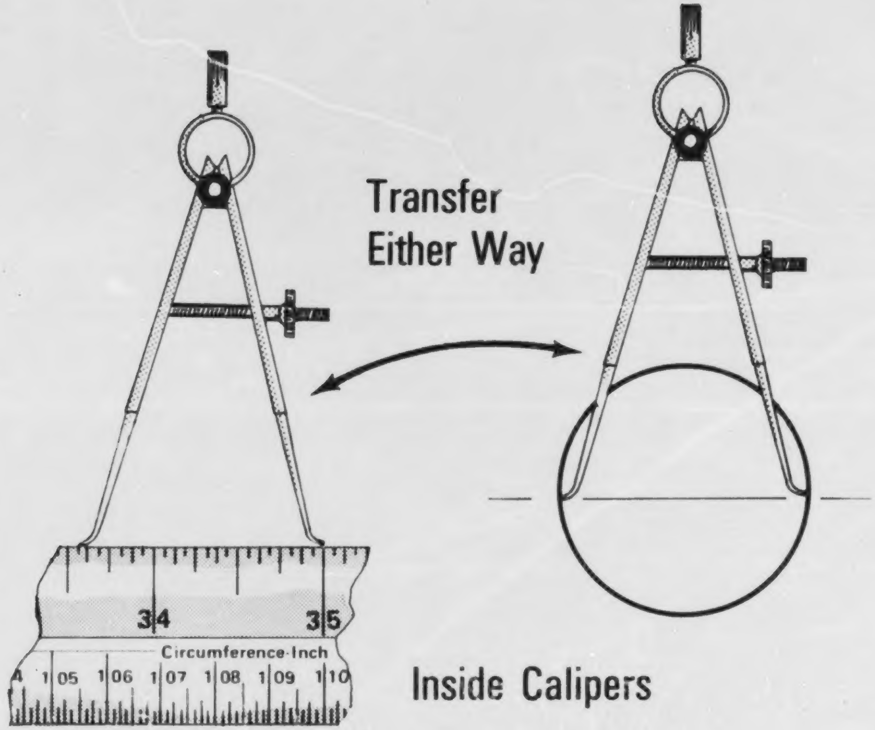
Slide Caliper Rule

Uses of Inside and Outside Calipers



Outside Calipers




34
35
Circumference-Inch
4
1 05
1 06
1 07
1 08
1 09
1 10

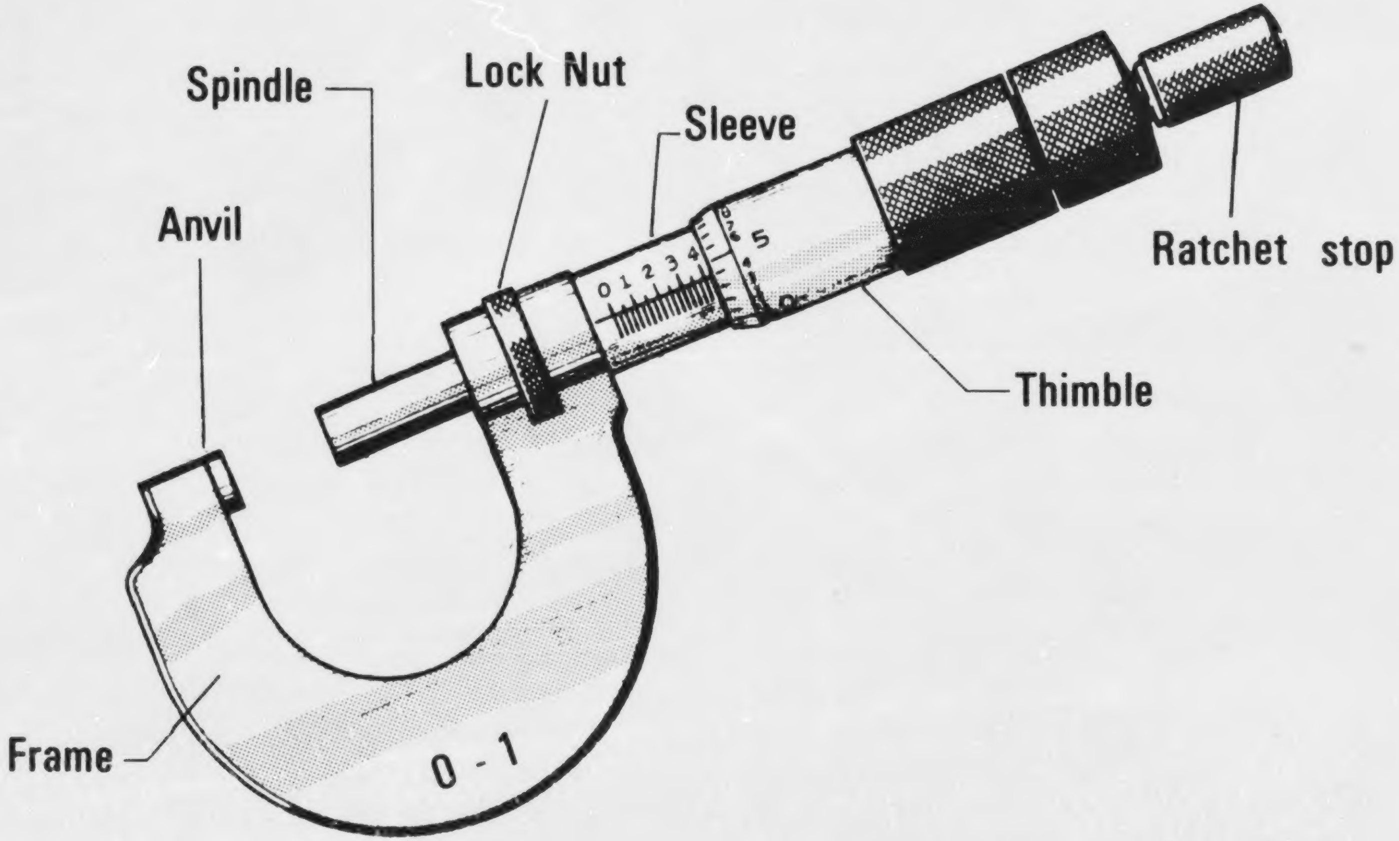
Transfer
Either Way

Inside Calipers

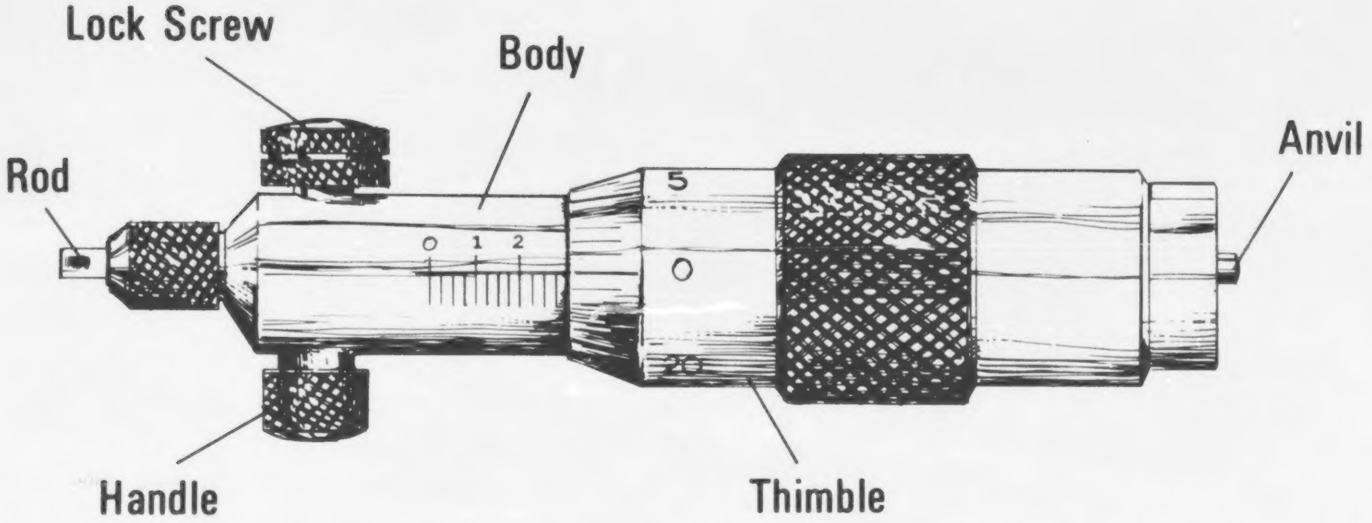
TM - 7

ACR I - 163-C

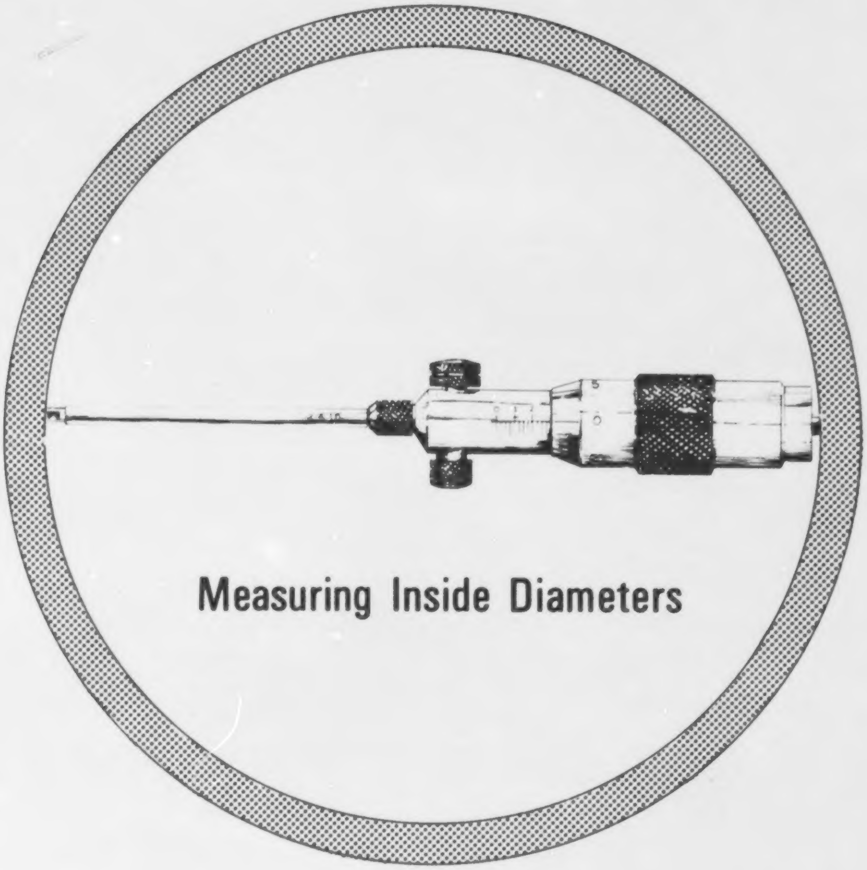
Parts of the Outside Micrometer


Spindle
Lock Nut
Sleeve
Anvil
Ratchet stop
Thimble
Frame
0 1 2 3 4
5
0
0 - 1

Parts of the Inside Micrometer

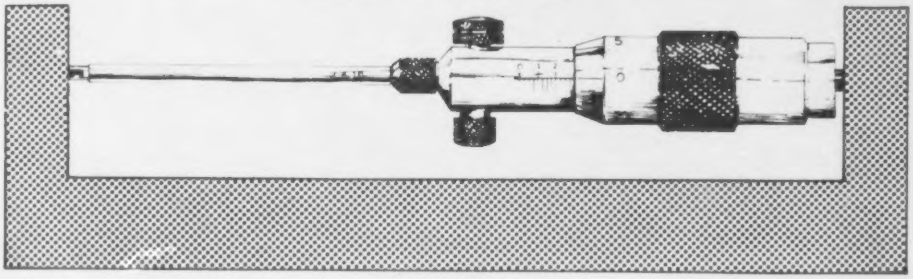

Lock Screw
Body
Anvil
Rod
0 1 2
5
0
20
Handle
Thimble

Uses of the Inside Micrometer

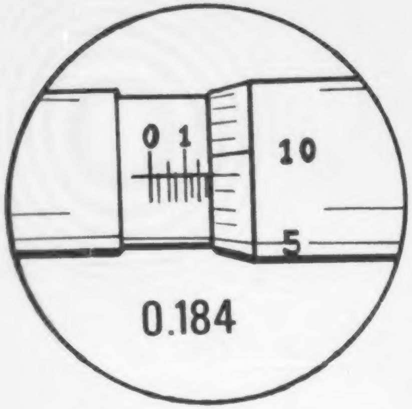


Measuring Inside Diameters

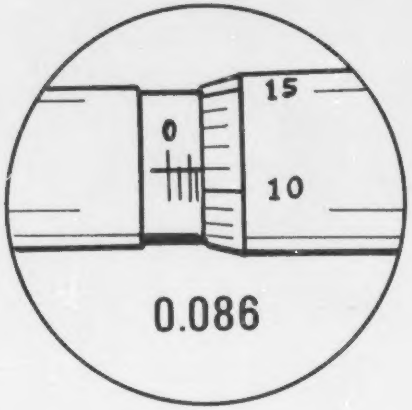
Measuring Widths



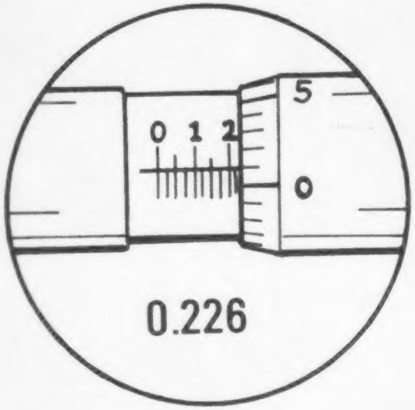
Reading a Micrometer



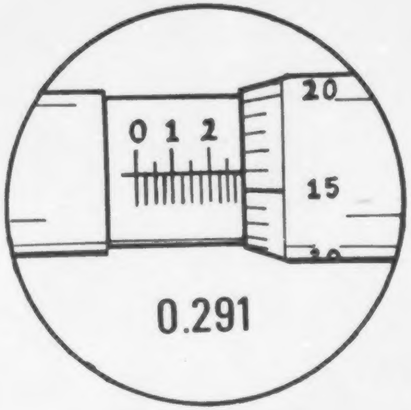
0.184



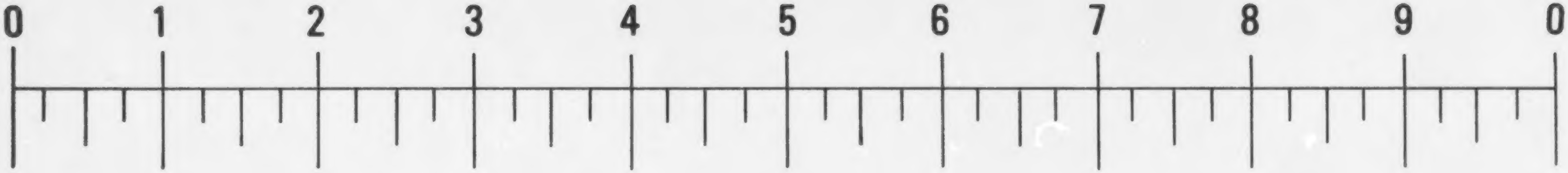
0.086



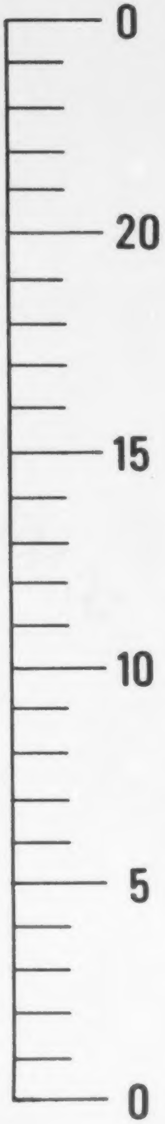
0.226



0.291


0
1
2
3
4
5
6
7
8
9
0

Sleeve Readings



Thimble

ACR I - 175-C

MEASURING
UNIT III

ASSIGNMENT SHEET #1--MEASURE LINES TO THE NEAREST QUARTER, EIGHTH AND SIXTEENTH OF AN INCH

1. Measure these lines to the nearest quarter of an inch.

   a. ____

   b. ____

   c. _____________

   d. ___________________________

   Answers

   a. ____________

   b. ____________

   c. ____________

   d. ____________

2. Measure these lines to the nearest eighth of an inch.

   a. ____

   b. __________________________________

   c. ____

   d. ____

   Answers

   a. ____________

   b. ____________

   c. ____________

   d. ____________

ASSIGNMENT SHEET #1

3. Measure these lines to the nearest sixteenth of an inch.

a. ____

b. ____________

c. ______________________________

d. ______________________________________

Answers

a. __________

b. __________

c. __________

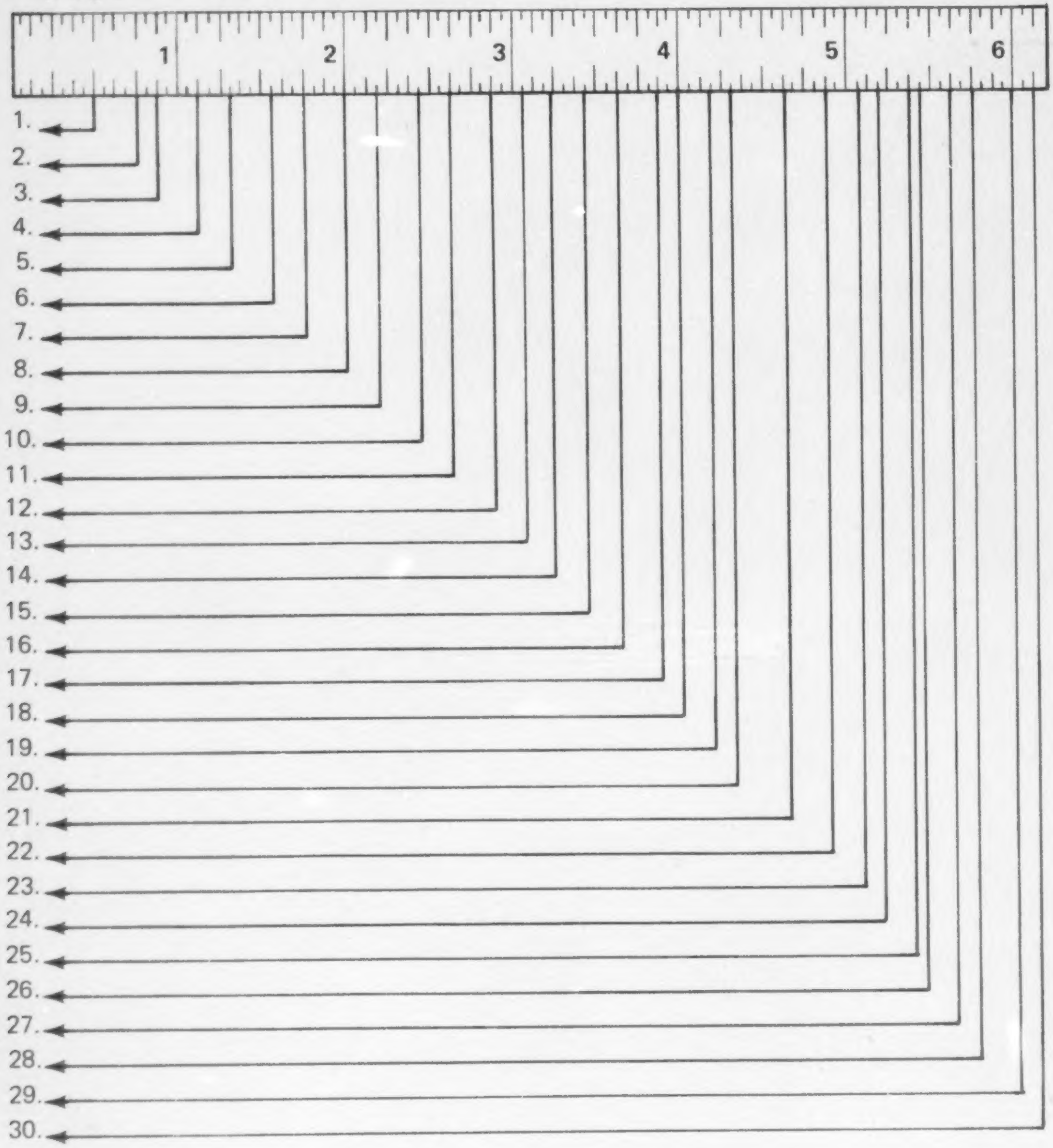
d. __________

MEASURING
UNIT III

ASSIGNMENT SHEET #2--READ A RULE

Determine the correct dimension for each arrow. Place answer on the arrow.

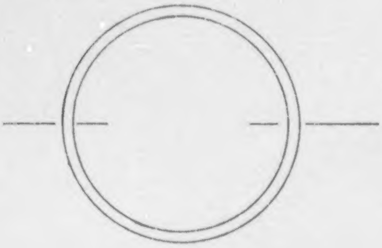
Example: Arrow 1 = 1/2"


1
2
3
4
5
6
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
15.
16.
17.
18.
19.
20.
21.
22.
23.
24.
25.
26.
27.
28.
29.
30.

MEASURING
UNIT III

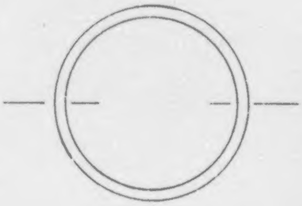
ASSIGNMENT SHEET #3--MEASURE INSIDE AND OUTSIDE DIAMETERS

Use the rule to measure the o.d. and i.d. of each tube. Indicate the correct dimensions in the space provided.



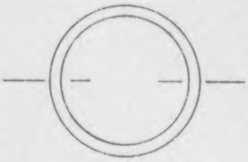
a. o.d. ______________

i.d. ______________



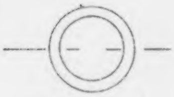
b. o.d. ______________

i.d. ______________



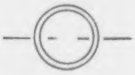
c. o.d. ______________

i.d. ______________



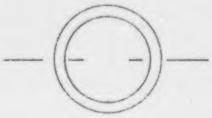
d. o.d. ______________

i.d. ______________



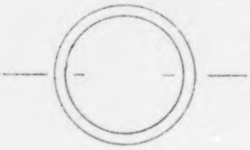
e. o.d. ______________

i.d. ______________



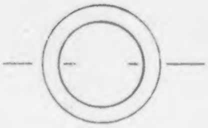
f. o.d. ______________

i.d. ______________



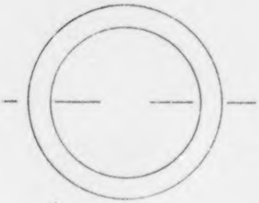
g. o.d. ______________

i.d. ______________



h. o.d. ______________

i.d. ______________



i. o.d. ______________

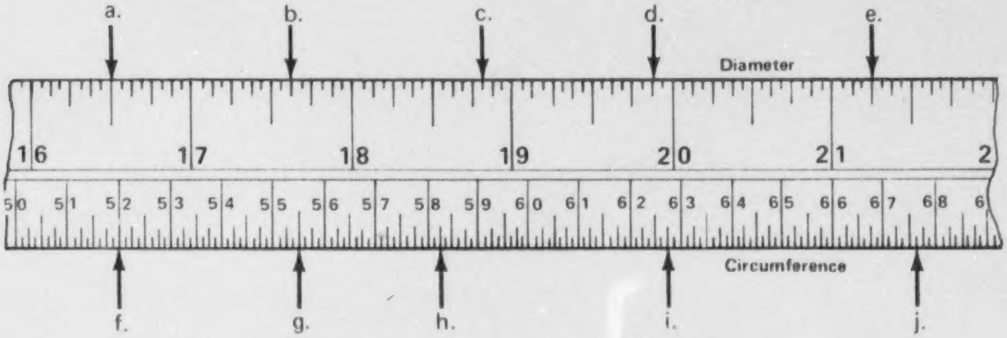
i.d. ______________

MEASURING
UNIT III

ASSIGNMENT SHEET #4--READ THE CIRCUMFERENCE RULE

1. Using the circumference rule shown, determine the circumference for the diameters a to e, and the corresponding diameters for the indicated circumferences f to j. Place answers in the columns below.

   (NOTE: Read diameters to closest 1/16" and circumferences to closest 1/8".)


a.
b.
c.
d.
e.
Diameter
16
17
18
19
20
21
2
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
6
Circumference
f.
g.
h.
i.
j.

a. = ____________

b. = ____________

c. = ____________

d. = ____________

e. = ____________

f. = ____________

g. = ____________

h. = ____________

i. = ____________

j. = ____________

k. = ____________

l. = ____________

m. = ____________

n. = ____________

o. = ____________

2. The diameters below are noted on the circumference rule. Find the corresponding circumferences for each diameter and place answers in the column above.

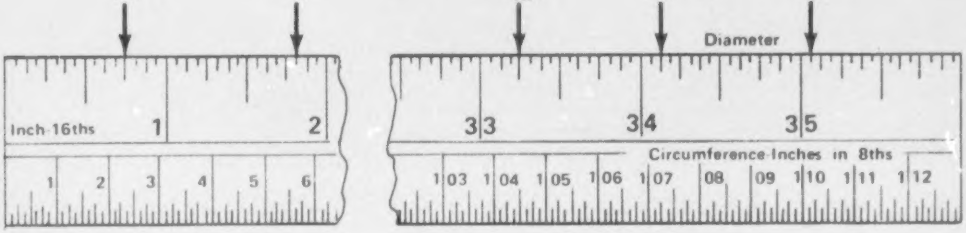
k. 33 1/4" dia.

l. 1 13/16" dia.

m. 3/4" dia.

n. 34 1/8" dia.

o. 35 1/16" dia.


m.
l.
Inch-16ths
1
2
1
2
3
4
5
6
k.
n.
o.
Diameter
33
34
35
Circumference Inches in 8ths
103
104
105
106
107
08
09
110
111
112

MEASURING
UNIT III

ASSIGNMENT SHEET #5--USE THE INSIDE AND OUTSIDE CALIPERS

1. Measure the i.d. of three pieces of tubing with a pair of calipers and transfer the measurement to a rule.

2. Measure the o.d. of three pieces of tubing with a pair of calipers and transfer the measurement to a rule.

3. Record measurements.

   (NOTE: Mark tubing for reference.)

4. I.D.

   a. ____________

   b. ____________

   c. ____________

5. O.D.

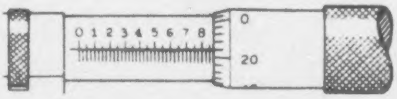
   a. ____________

   b. ____________

   c. ____________

MEASURING
UNIT III

ASSIGNMENT SHEET #6--READ THE MICROMETER SETTINGS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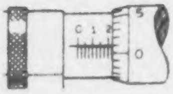

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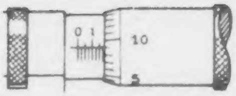

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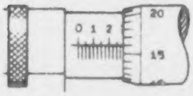

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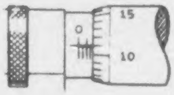

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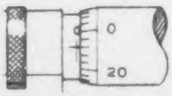

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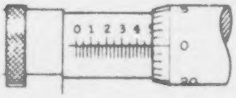

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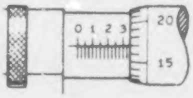

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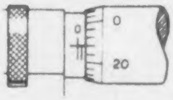

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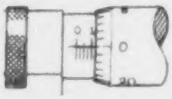

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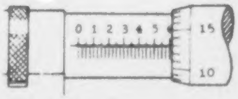
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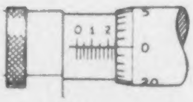
15
10

11



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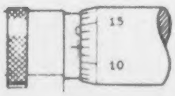

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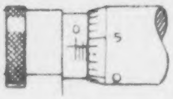

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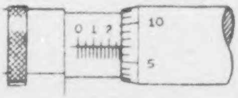

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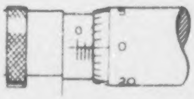

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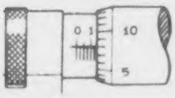

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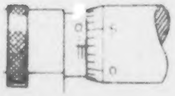

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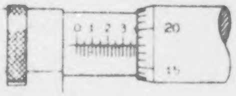

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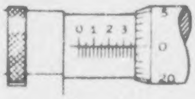

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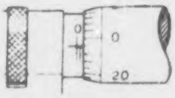

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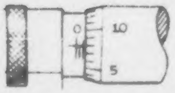

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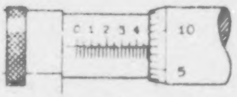

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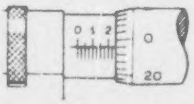

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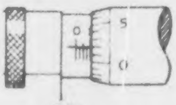

25

ANS.

1 ________
2 ________
3 ________
4 ________
5 ________
6 ________
7 ________
8 ________
9 ________
10 ________
11 ________
12 ________
13 ________
14 ________
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16 ________
17 ________
18 ________
19 ________
20 ________
21 ________
22 ________
23 ________
24 ________
25 ________

MEASURING
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. a. 3 1/4"
   b. 4 1/2"
   c. 1"
   d. 2"
2. a. 4 3/4"
   b. 2 1/2"
   c. 3 5/8"
   d. 4 1/4"
3. a. 4 1/16"
   b. 1 1/16"
   c. 2 5/8"
   d. 3 5/16"

Assignment Sheet #2

2. 3/4"
3. 7/8"
4. 1 1/8"
5. 1 5/16"
6. 1 9/16"
7. 1 3/4"
8. 2"
9. 2 3/16"
10. 2 7/16"
11. 2 5/8"
12. 2 7/8"
13. 3 1/16"
14. 3 1/4"
15. 3 7/16"
16. 3 5/8"
17. 3 7/8"
18. 4"
19. 4 3/16"
20. 4 5/16"
21. 4 5/8"
22. 4 7/8"
23. 5 1/16"
24. 5 3/16"
25. 5 3/8"
26. 5 7/16"
27. 5 5/8"
28. 5 3/4"
29. 6"
30. 6 1/8"

Assignment Sheet #3

a. O.D. 1 3/8" I.D. 1 1/4"
b. O.D. 1 1/8" I.D. 1"
c. O.D. 7/8" I.D. 3/4"
d. O.D. 1/2" I.D. 3/8"
e. O.D. 3/8" I.D. 5/16"
f. O.D. 5/8" I.D. 1/2"
g. O.D. 13/16" I.D. 11/16"
h. O.D. 11/16" I.D. 1/2"
i. O.D. 1 1/8" I.D. 7/8"

Assignment Sheet #4

a. 51 7/8"
b. 55 3/8"
c. 59
d. 62 1/2"
e. 66 7/8"
f. 16 9/16"
g. 17 11/16"
h. 18 9/16"
i. 19 15/16"
j. 21 1/2"
k. 104 1/2"
l. 5 5/8"
m. 2 3/8"
n. 107 1/4"
o. 110 1/8"

Assignment Sheet #6

1. 0.871
2. 0.226
3. 0.184
4. 0.291
5. 0.086
6. 0.023
7. 0.500
8. 0.342
9. 0.047
10. 0.125
11. 0.613
12. 0.250
13. 0.012
14. 0.079
15. 0.282
16. 0.100
17. 0.133
18. 0.053
19. 0.393
20. 0.375
21. 0.049
22. 0.058
23. 0.483
24. 0.249
25. 0.102

MEASURING
UNIT III

JOB SHEET #1--USE THE OUTSIDE MICROMETER

I. Tools and materials

A. Micrometer 0-1.000" size

B. Workpieces

1. 5 assorted new fractional drill bits

2. 5 assorted new letter size drill bits

3. 5 assorted pieces of motor shafts or tubing

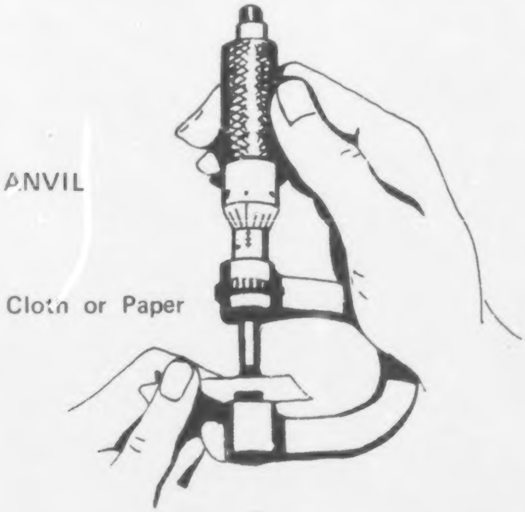
(NOTE: All workpieces should be numbered or lettered for reference.)

II. Procedure

(NOTE: Workpieces to be measured must be clean and free of burrs, nicks, or dents.)

A. Clean the spindle and anvil of the micrometer (Figure 1)

Figure 1



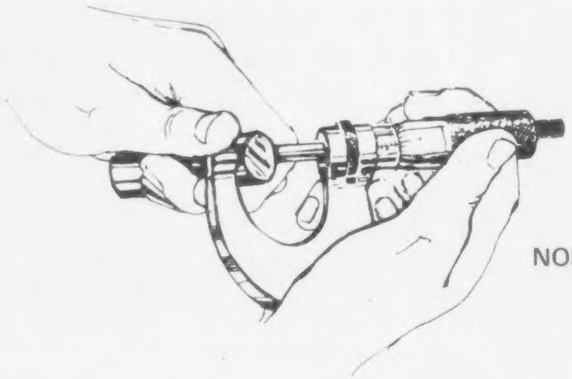
CLEAN SPINDLE AND ANVIL

B. Check the micrometer at zero reference

JOB SHEET #1

C. Hold the micrometer in the right hand and the workpiece in the left hand to measure nonstationary objects (Figure 2)

Figure 2

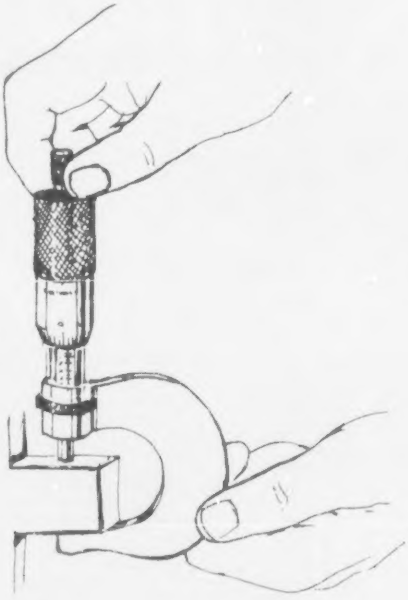


NON STATIONARY OBJECT

D. Hold the micrometer in both hands to measure a stationary object (Figure 3)

Figure 3

STATIONARY OBJECT



JOB SHEET #1

E. Roll micrometer along palm of hand or forearm for quick adjustment (Figure 4)

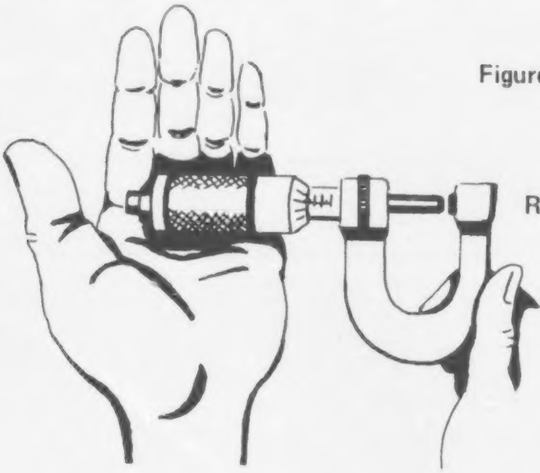
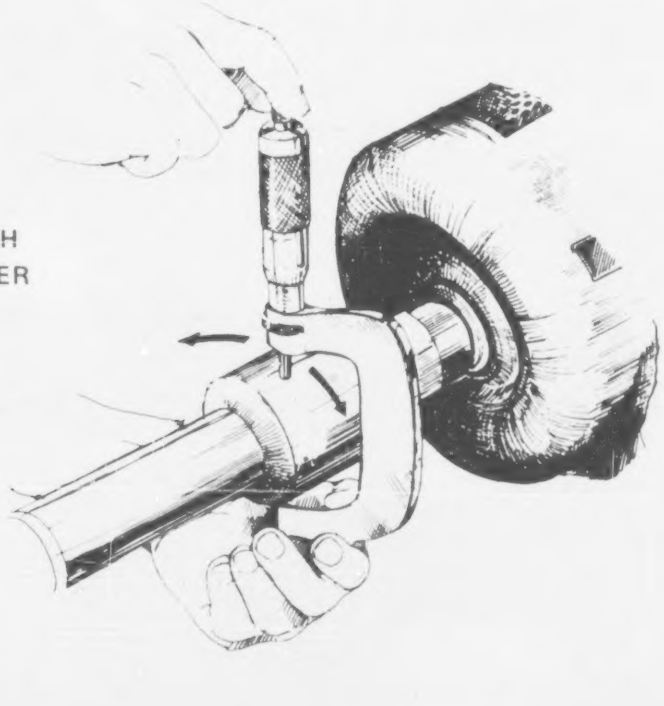

ROLL FOR QUICK ADJUSTMENT

Figure 4

F. Turn the thimble of the micrometer until the anvil and spindle contact the workpiece

G. Hold the anvil steady and move the spindle lightly over the workpiece to locate the true diameter (Figure 5)

Figure 5


WORK BACK AND FORTH
TO FIND TRUE DIAMETER

JOB SHEET #1

H. Use ratchet stop or light sense of feel to determine exact measurement

I. Observe micrometer readings

(NOTE: Lock nut can be turned to hold measurement if micrometer must be removed from workpiece. Spindle must be unlocked before resetting to a new measurement.)

J. List the readings according to the letter or number on the workpiece

K. Return micrometer to its correct storage area when finished

(NOTE: The spindle and anvil of the micrometer should be left open when stored.)

L. Hand in the listed readings to the instructor for evaluation

MEASURING
UNIT III

JOB SHEET #2--USE THE INSIDE MICROMETER

I. Tools and materials

A. An inside micrometer set

B. 10 assorted bored workpieces and drilled holes of varying sizes

(NOTE: All workpieces should be numbered or lettered for references.)

II. Procedure

(NOTE: Workpieces to be measured must be clean and free of burrs, nicks, or dents.)

A. Clean the contact points and accessories of the inside micrometer

B. Check the inside micrometer for accuracy

C. Select the correct extension rod and collar for the required measurement

1. Observe base unit size and range of movement

Example: 2.000" base unit with a 0.500" movement measures from 2.000" to 2.500"

2. Add extension collar to utilize full range of extension rod

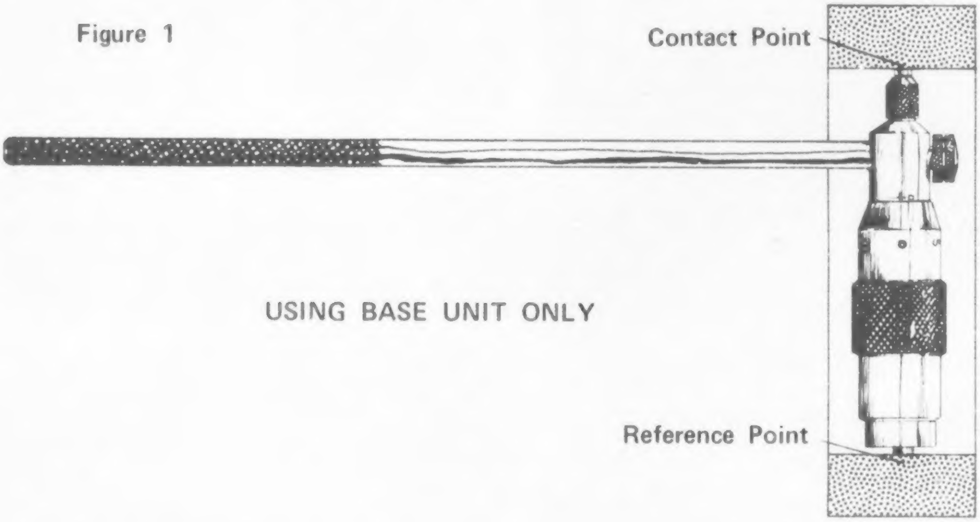
3. Use tools to assemble and disassemble accessories

JOB SHEET #2

D. Establish a good reference and contact point during measurement (Figure 1)

(NOTE: Support inside micrometer in a comfortable position during use. Add extension handle for small hole or deep hole application.)

Figure 1



USING BASE UNIT ONLY

E. Move the contact point from side to side ("centralize") to find the true diameter of the workpiece (Figure 1)

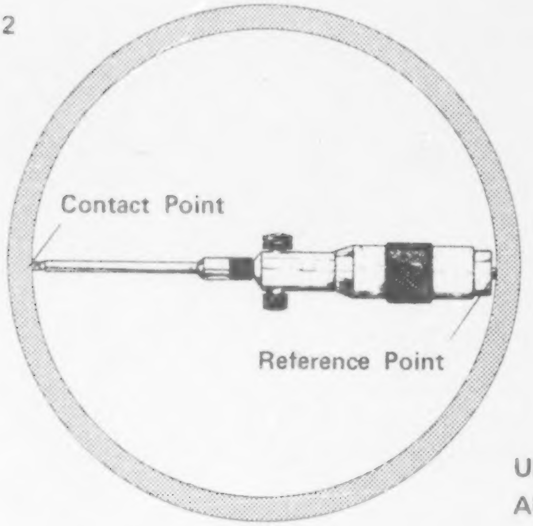
(NOTE: Use light sense of touch on the thimble of the base unit.)

JOB SHEET #2

F. Observe the total reading from the base unit of the inside micrometer

(NOTE: Add extension rod and/or extension collar (if used) to the total measurement. See Figure 2.)

Figure 2



USING EXTENSION ROD AND EXTENSION COLLAR

G. List the readings according to the letter or number on the workpiece

H. Replace inside micrometer set in original order after use

MEASURING
UNIT III

TEST

1. Match the terms on the right to the correct definitions.

_____a. Length of a straight line through the center of a circular object

_____b. Setting of limits or bounds according to a predetermined standard

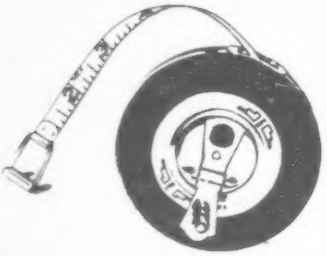
_____c. Unit of measure consisting of twelve equal parts called inches

_____d. Distance around a circle

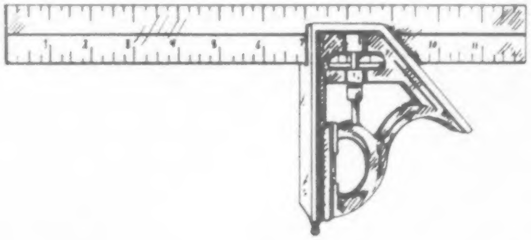
_____e. Measuring instrument that is divided into feet, inches, and fractions of inches

1. Circumference
2. Foot
3. Measure
4. Diameter
5. Rule

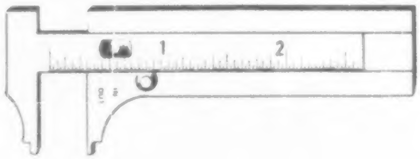
2. Identify the measuring instruments.



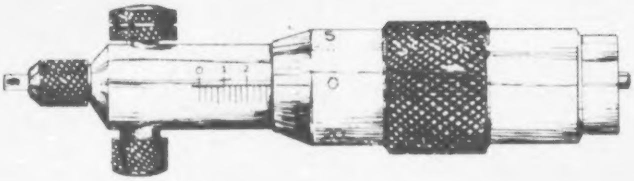
a. ______________________________



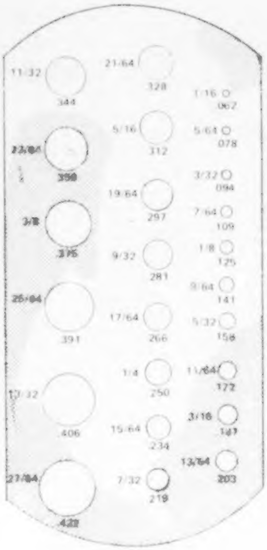
b. ______________________________



c. ______________________________


0 1 2

d. ______________________________


11/32
.344
21/64
.328
1/16
.062
23/64
.359
5/16
.312
5/64
.078
3/32
.094
19/64
.297
3/8
.375
7/64
.109
9/32
.281
1/8
.125
25/64
.391
9/64
.141
17/64
.266
5/32
.156
1/4
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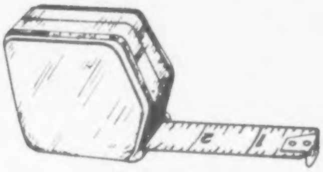
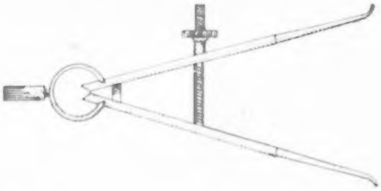
27/64
.422
7/32
.219

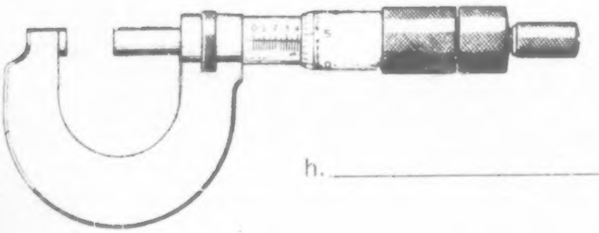

2
1

f. ______________________________

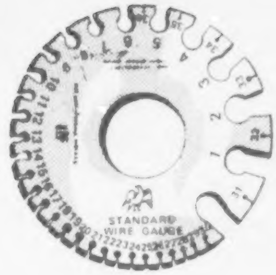
e. ______________________________



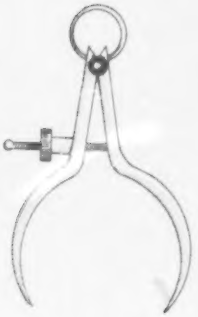
g. ______________________________



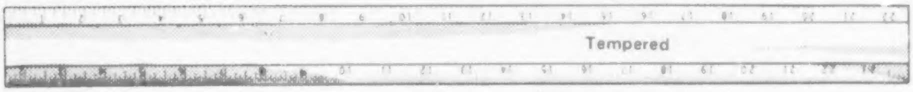
h. ______________________________


STANDARD
WIRE GAUGE

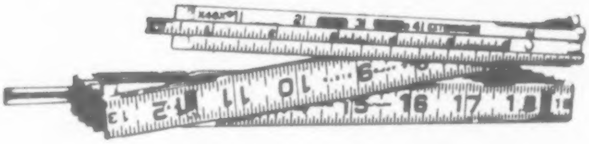
i. ______________________



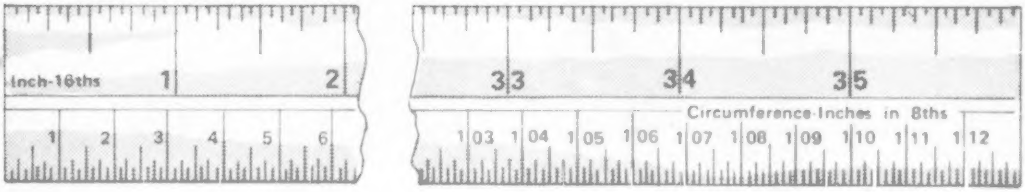
j. ______________________


Tempered

k. ______________________



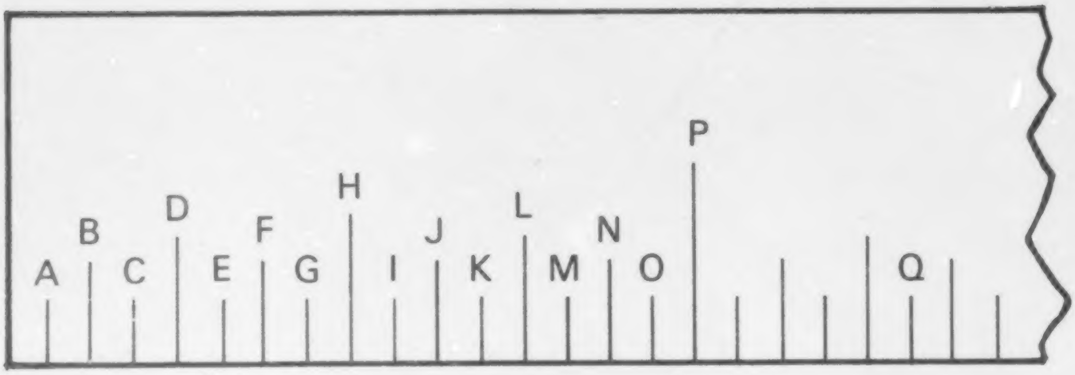
l. ______________________


Inch-16ths
Circumference-Inches in 8ths

m. ______________________

3. Read the sixteenth's rule.

Example: P = 1"


A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q

a. ______________ b. ______________ c. ______________

d. ______________ e. ______________ f. ______________

g. ______________ h. ______________ i. ______________

j. ______________ k. ______________ l. ______________

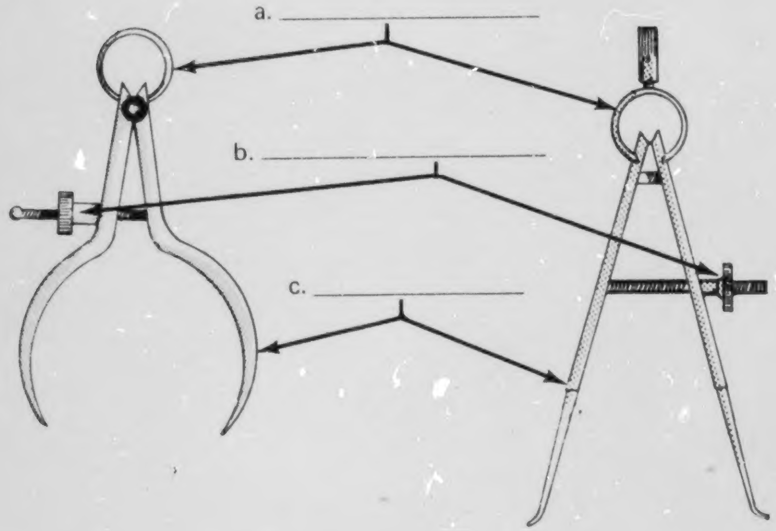
m. ______________ n. ______________ o. ______________

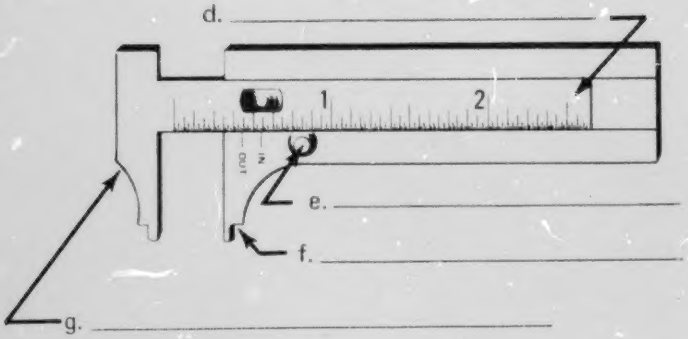
p. ______________ q. ______________

4. List five guidelines for the use and care of rules and steel tapes.
   - a.
   - b.
   - c.
   - d.
   - e.

5. List the procedures for the use of drill and wire gauges.
   - a. Drill gauge
     - 1)
     - 2)
   - b. Wire gauge
     - 1)
       - a)
       - b)
     - 2)
       - a)
       - b)

6. Identify the major parts of the calipers.




d. ______________________
1
2
OUT
IN
e. ______________________
f. ______________________
g. ______________________

7. List the rules for use and care of calipers.

   a. Use of calipers

      1)

      2)

      3)

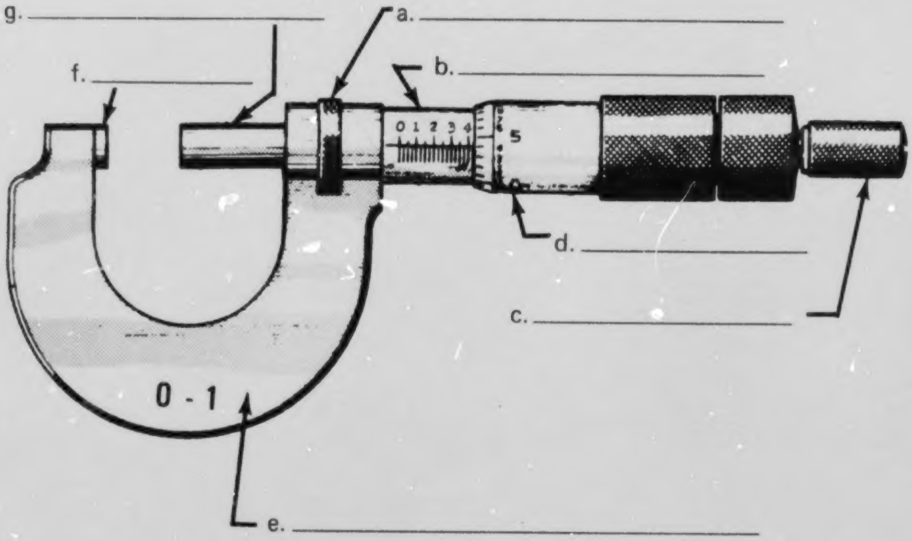
   b. Care of calipers

      1)

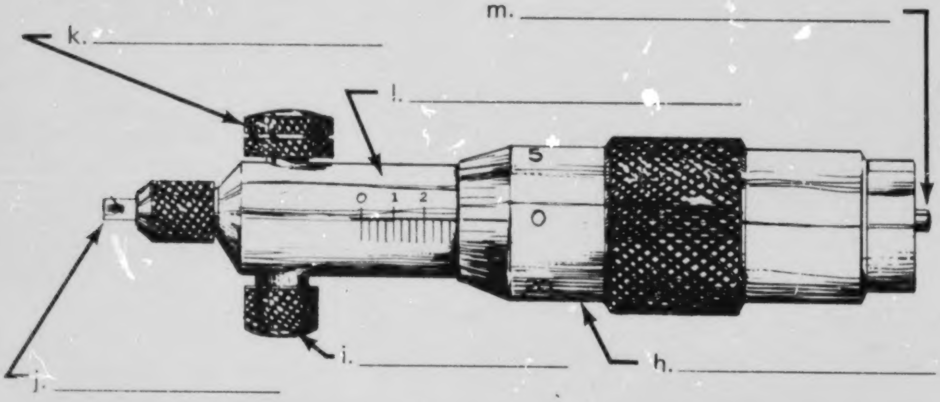
      2)

      3)

8. Identify the major parts of the micrometers.



g. ____________________
a. ____________________
f. ____________
b. ____________________
0 1 2 3 4
5
d. ______________
c. ______________
0 - 1
e. ____________________________


m. ____________________
k. ____________________
l. ____________________
5
0 1 2
0
i. ____________________
h. ____________________
j. ____________________

9. List seven rules for the care of micrometers.

   a.

   b.

   c.

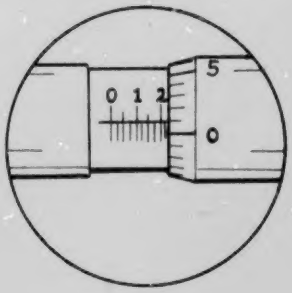
   d.

   e.

   f.

   g.

10. Read the micrometer setting.



Answer __________

11. Demonstrate the ability to:

    a. Measure lines to the nearest quarter, eighth, and sixteenth of an inch.

    b. Read a rule.

    c. Measure inside and outside diameters.

    d. Read the circumference rule.

    e. Use the inside and outside calipers.

    f. Read the micrometer settings.

    g. Use the outside micrometer.

    h. Use the inside micrometer.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

MEASURING
UNIT III

ANSWERS TO TEST

1. a. 4
   b. 3
   c. 2
   d. 1
   e. 5

2. a. Steel tape
   b. Combination square
   c. Slide caliper
   d. Inside micrometer
   e. Drill gauge
   f. Steel tape
   g. Inside caliper
   h. Outside micrometer
   i. Wire gauge
   j. Outside caliper
   k. Steel rule
   l. Folding rule
   m. Circumference rule

3. a. 1/16"
   b. 1/8"
   c. 3/16"
   d. 1/4"
   e. 5/16"
   f. 3/8"
   g. 7/16"
   h. 1/2"
   i. 9/16"
   j. 5/8"
   k. 11/16"
   l. 3/4"
   m. 13/16"
   n. 7/8"
   o. 15/16"
   p. 1"
   q. 1 3/8"

4. Any five of the following:
    a. Use the proper length and graduation
    b. Use finest graduation for accuracy
    c. Use a good quality rule
    d. Never bend or distort a steel rule
    e. Use only for intended purpose
    f. Rewind steel tapes slowly
    g. Start measurement at one inch graduation for accuracy
    h. Use rule on edge for accurate reading
    i. Use lower edge of circumference rule for figuring circumferences only
5. a. Drill gauge
        1) Locate hole which drill bit fits
        2) Read drill bit size
    b. Wire gauge
        1) Measuring metal thickness
            a) Slide slot over sheet metal
            b) Read thickness of metal
        2) Measuring wire circumference
            a) Insert wire into round opening
            b) Read wire size
6. a. Spring
    b. Adjusting nut
    c. Leg
    d. Scale
    e. Clamping screw
    f. Fixed jaw
    g. Movable jaw

7. a. Use of calipers
    1) Fit part to be measured between caliper jaws or legs to measure outside diameter
    2) Mark on movable jaw will indicate the diameter on the scale
    3) Use inside and outside calipers to transfer measurement to a scale or pattern

   b. Care of calipers
    1) Do not drop
    2) Keep clean
    3) Do not overtighten clamping screw or adjusting nut

8. a. Lock nut
   b. Sleeve
   c. Ratchet stop
   d. Thimble
   e. Frame
   f. Anvil
   g. Spindle
   h. Thimble
   i. Handle
   j. Rod
   k. Lock screw
   l. Body
   m. Anvil

9. a. Keep instrument away from heat, abrasive dust, moisture, oil, and grease
   b. Occasionally clean and lubricate instrument
   c. Check instrument for accuracy before use
   d. Do not overtighten during measurement
   e. Properly store
   f. Handle instrument in correct manner
   g. Use instrument only for intended use

10. 0.226

11. Performance skills evaluated to the satisfaction of the instructor

PROGRESS CHART

Tools

____
Date

Air Conditioning and Refrigeration

Section C

What The Trainee Should Be Able To Do

Names	Grind a flat tip screwdriver	Grind the head of chisel or punch	Sharpen a chisel	Cut external threads	Cut internal threads	Sharpen a twist drill bit	Measure lines to nearest 1/4, 1/8 and 1/16 inch	Read a rule	Measure inside and outside diameters	Read the circumference rule	Use the inside and outside calipers	Read the micrometer settings	Use the outside micrometer	Use the inside micrometer								
1																						
2																						
3																						
4																						
5																						
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20																						

PROGRESS CHART

Tools

____
Date

Air Conditioning and Refrigeration

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1														
2														
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20														

TUBING
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to distinguish between different types of tubing and fittings. He should be able to select the proper size and type of tubing and fittings needed for a particular job. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with tubing to the correct definitions or descriptions.
2. Discuss the kinds of tubing.
3. Distinguish between nominal size copper tubing applications and ACR copper tubing applications.
4. Match the color coding of cartons and tags to the type of tubing
5. List the applications of aluminum tubing.
6. List the applications of steel tubing.
7. Identify tube and flexible refrigerant hose fittings.
8. Discuss the construction and use of flexible refrigerant hose in this trade.

TUBING
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information and assignment sheets.

   F. Show students actual fittings and tubing.

   G. Have students identify the actual components.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment sheet.

   D. Complete activities assigned by instructor.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Fittings

      2. TM 2--Fittings (Continued)

      3. TM 3--Fittings (Continued)

4. TM 4--Quick Connect Fittings

5. TM 5--Refrigerant Hose

D. Test

E. Answers to test

II. References:

A. Althouse, Andrew D., Turnquist, Carl H., and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Co., 1975.

B. *Drawn Coiled Seamless Tube.* Pittsburgh, Pennsylvania: Aluminum Company of America, January 24, 1976.

C. *Field Repair of Aluminum Refrigeration Coils.* Des Plaines, Illinois: The Aluminum Association, 1972.

D. *Copper Tube Handbook.* New York, New York: Copper Development Association.

TUBING
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Tube--Fluid carrying pipe which has a thin wall

B. Nominal size tubing--Type of tubing used on water lines, drains, and in other applications, but never in connection with refrigerants

(NOTE: This tubing is not to be used for air-conditioning and refrigeration lines which carry refrigerant.)

C. ACR tubing--Tubing manufactured specifically for air conditioning and refrigeration that is free of contaminants, sealed, and is measured by outside diameter

D. Annealed tubing--Tubing which has been heat treated to soften it for easy bending

(NOTE: This tubing is generally supplied in 50 ft. rolls.)

E. Hard drawn--Rigid copper tubing that should not be bent

(NOTE: This tubing is supplied in 20 ft. lengths.)

F. Flare--Enlargement at the end of a piece of tubing which is made at a 45° angle and enables a fitting to be placed on the tubing

G. Sweat--Method of soldering tubing

(NOTE: A sweat fitting is one that must be soldered onto the line.)

H. Compression fitting--Tubing connector consisting of a nut, sleeve, and union

I. Quick connect--Fitting which permits fast and easy connecting and disconnecting of refrigerant lines

INFORMATION SHEET

II. Kinds of tubing

A. Copper

(NOTE: Copper is the most widely used tubing in this trade.)

1. Types
    a. Nominal size
    b. ACR
2. Temper
    a. Annealed
    b. Hard drawn
3. Wall thickness

    (NOTE: These wall thicknesses are in descending order from heavy wall to thin wall.)

    a. K
    b. L
    c. M
    d. DWV
4. Advantages
    a. High thermal conductivity

    (NOTE: Silver is the only metal that has a higher rate of conductivity, but due to expense it is not used very often.)

    b. Easy to solder and braze
    c. Easy to bend and flare
    d. High resistance to corrosion

B. Aluminum

1. Types
    a. Coiled seamless tube
    b. Thin wall

INFORMATION SHEET

2. Contamination prevention
    a. Internally cleaned
    b. Sealed ends
3. Sizes--5/16" to 3/4" o.d.
4. Advantages
    a. High thermal conductivity
    b. Easy to bend
    c. Easy to flare

    (NOTE: A double flare is recommended.)
5. Disadvantages
    a. Porous
    b. Easily work hardened
    c. Creates corrosive action
6. Connections
    a. Aluminum flare nuts

    (NOTE: The use of any other type of metal flare nuts would create a corrosive action.)
    b. Special solder
    c. Inert gas welding
    d. Epoxy

(NOTE: When connecting aluminum to copper, care must be used to prevent a corrosive action.)

C. Steel
1. Types
    a. Thin wall
    b. Stainless

INFORMATION SHEET

2. Connections
    a. Flaring
    b. Brazing

III. Applications of copper tubing for nominal size and ACR

A. Nominal size

1. Type M
    a. Underground water service
    b. Water distribution systems
    c. Chilled water systems

       (NOTE: This type of tubing is used for this application up to 1" i.d.)
    d. Hot water heating and low pressure steam

       (NOTE: This type of tubing is used for this application up to 1 1/4" i.d.)
2. Type L
    a. Underground water service where coils are permitted
    b. Hydronic heating where coils are used
    c. Water heating or condensate return
3. Type K
    a. Heavy wall tubing where self-support is vital
    b. Severe corrosion conditions
4. Type DWV
    a. Drain waste pipes
    b. Hot water heating where larger than 1 1/4" is needed

B. ACR

1. Air conditioning
    a. Suction line
    b. Liquid line

INFORMATION SHEET

        c. Evaporator coils
        d. Condenser coils
        e. Discharge line

    2. Refrigeration
        a. Suction line
        b. Liquid line
        c. Evaporator coils
        d. Condenser coils
        e. Discharge line

(NOTE: Refrigerant carrying tubing is available in "K", "L", and "M" wall thicknesses. The majority of the ACR tubing is of the "L" wall thickness.)

IV. Color coding of tubing cartons and tags

- A. Green--Type K
- B. Blue--Type L
- C. Red--Type M
- D. Yellow--Type DWV

V. Applications of aluminum tubing

- A. Domestic refrigerators
    - 1. Evaporators
    - 2. Suction lines
- B. Central air-conditioner condenser
- C. Automotive air conditioner
    - 1. Condenser
    - 2. Liquid line
    - 3. Receiver
    - 4. Evaporator

INFORMATION SHEET

VI. Applications of steel tubing

A. Compression refrigeration

1. Condensers
2. Liquid lines
3. Oil coolers

(NOTE: Steel lines are used often on domestic refrigeration.)

B. Absorption refrigeration--All refrigerant carrying components must be steel

VII. Tube and flexible refrigerant hose fittings (Transparencies 1, 2, and 3)

A. Flared fittings

1. Seal cap
2. Flare gasket
3. Cross
4. Union elbow
5. Female elbow
6. Reducing union elbow
7. Female swivel elbow
8. Short nut

   (NOTE: This nut is also made with slits or holes to be used in low temperature applications which prevents the nut from loosening due to expansion and contraction. This type of nut is called a frost free nut.)

9. Long nut
10. Cap nut
11. Flare cap
12. Nut-heavy pattern
13. Plug

INFORMATION SHEET

14. Union tee
15. Reducing tee--Small to large
16. Reducing tee--Large to small
17. Union
18. Female connector
19. Female union
20. Tee--Female to male
21. Reducing union
22. Reducer
23. Swivel

B. Flare to pipe fittings

1. Male elbow
2. 45° male elbow
3. Male branch tee
4. Male run tee
5. Female coupling
6. Male connector

C. Compression fittings

1. Sleeve
2. Nut
3. Union
4. Compression to pipe union
5. Union elbow
6. Union tee

INFORMATION SHEET

  7. Female connector

  8. Female elbow

 (NOTE: Compression fittings are not suitable for refrigerant lines.)

D. Sweat fittings

  1. Coupling

  2. Coupling reducer

  3. Return bends

  4. Suction line traps

  5. 90° elbow

  6. 45° elbow

  7. Street elbow

   (NOTE: Sweat elbows are available with either a long or short bend radius.)

  8. Cap

  9. Tee

  10. Sweat to pipe

  11. Sweat to flare

  12. Sweat to flare swivel

E. Hose fittings

  1. Flare

   a. Male

   b. Female

  2. Splice

   a. Tee

   b. Straight

 (NOTE: These fittings are primarily used on automotive air conditioning.)

INFORMATION SHEET

F. Quick connect fittings (Transparency 4)

1. Cutter type

   (NOTE: This type of fitting is used on precharged refrigerant lines and the refrigerant charge will be lost if the line is removed after it has once been installed on a system.)

2. Spring loaded seal

   (NOTE: This type of fitting is used on precharged refrigerant lines and it may be removed from a system without losing the charge.)

VIII. Flexible refrigerant hose (Transparency 5)

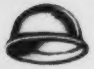
A. Construction

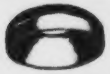
1. Outer core heat resistant ventilated neoprene
2. Double layer rayon cord
3. Soft dense refrigeration grade neoprene inner liner

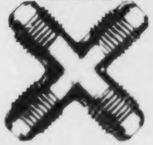
B. Use

1. Primarily automotive air conditioning
2. Central air conditioning where complicated bends might be encountered
3. Units that have a tendency to vibrate excessively

Fittings


Seal Cap


Flare Gasket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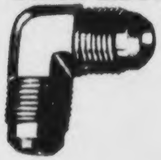
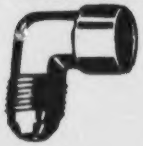
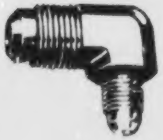
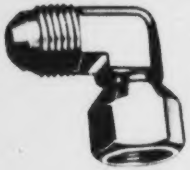
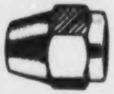
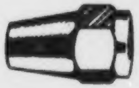

Union Elbow

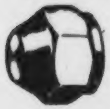

Female Elbow

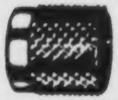

Reducing Union Elbow

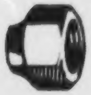

Female Swivel Elbow

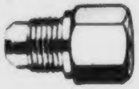

Short Nut

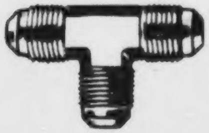

Long Nut

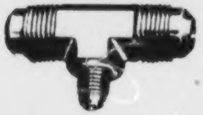

Cap Nut

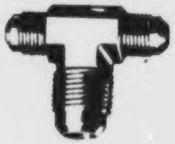

Flare Cap

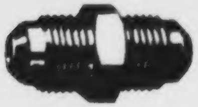

Nut-Heavy Pattern

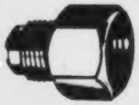

Plug

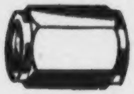

Union Tee

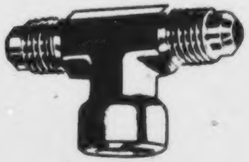

Reducing Tee Small To Large

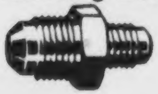

Reducing Tee Large to Small

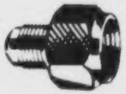

Union

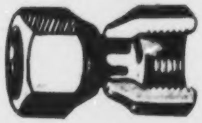

Female Connector


Female Union


Tee Female To Male


Reducing Union


Reducer

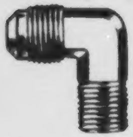

Swivel

Fittings

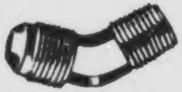
(Continued)

Flare to Pipe

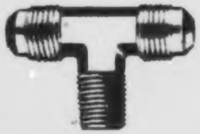
Male Elbow



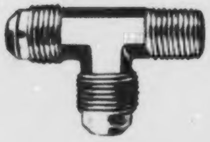
45° Male Elbow



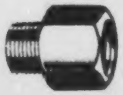
Male Branch Tee



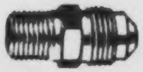
Male Run Tee



Female Coupling

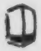


Male Connector

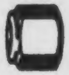


Compression

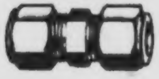
Sleeve



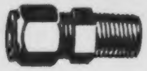
Nut



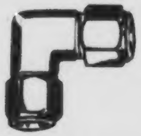
Union



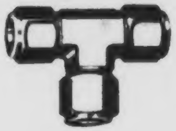
Compression To Pipe Union



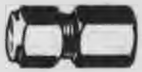
Union Elbow



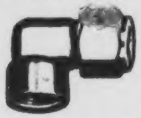
Union Tee



Female Connector

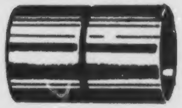


Female Elbow

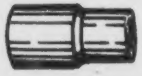


Sweat

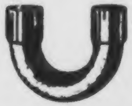
Coupling



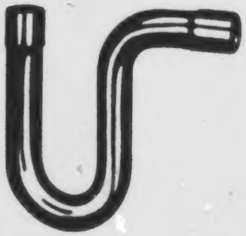
Coupling Reducer



Return Bend



Suction Line Traps

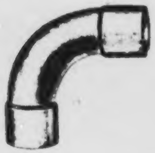


Fittings

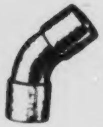
(Continued)

Sweat

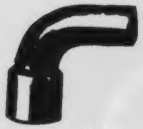
90° Elbow



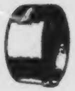
45° Elbow



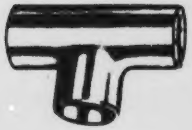
Street Elbow



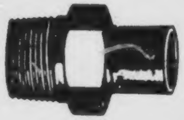
Cap



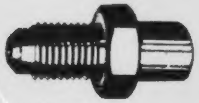
Tee



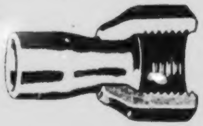
Sweat To Pipe



Sweat To Flare

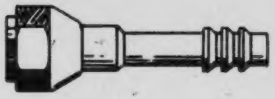


Sweat To Flare Swivel

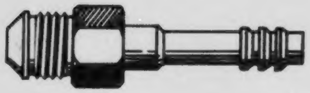


Hose Fittings

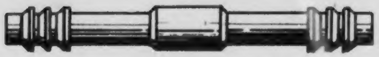
Female Flare



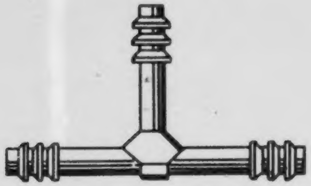
Male Flare



Straight Splice

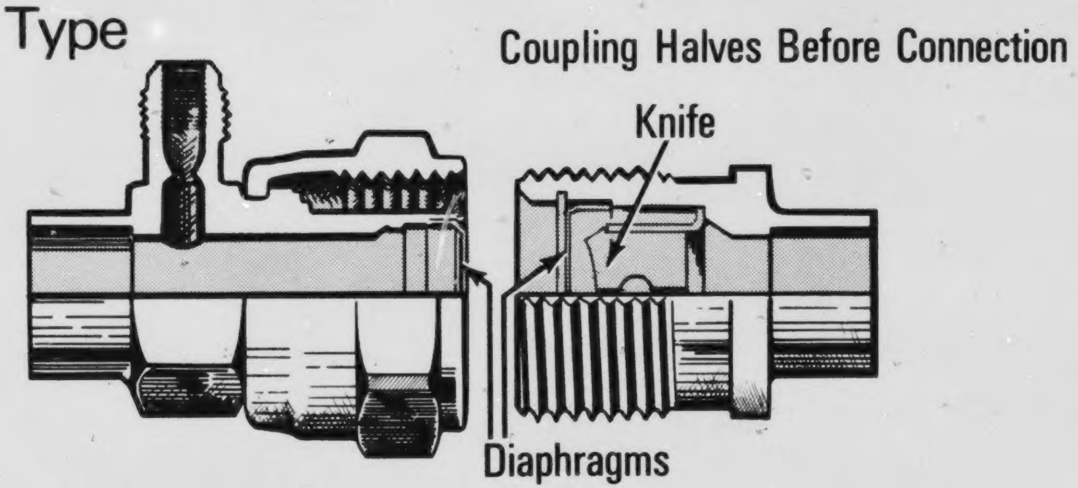


Tee Splice

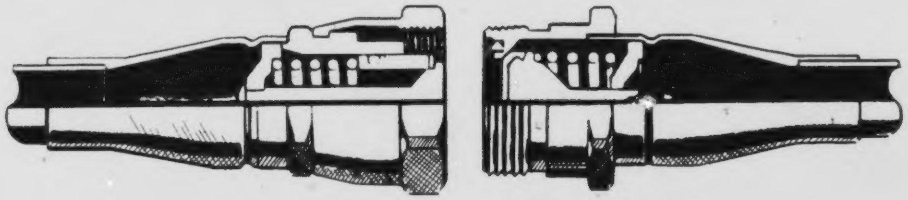


Quick-Connect Fittings

Cutter Type

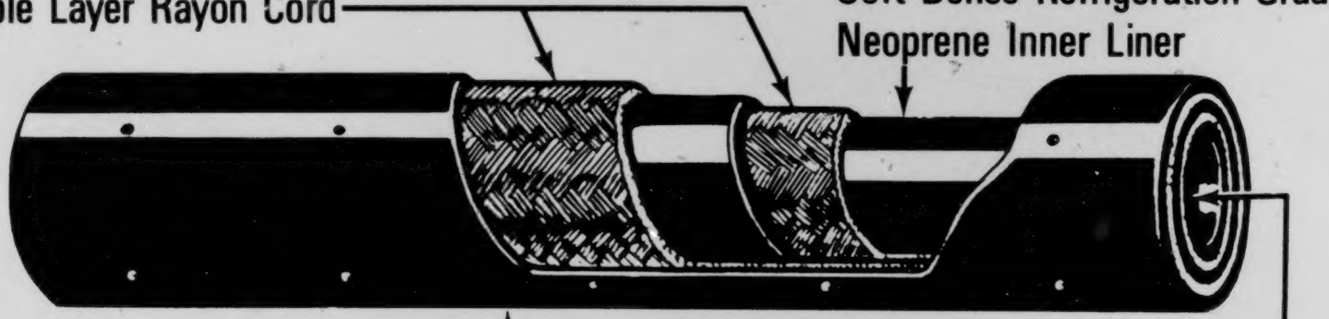

Coupling Halves Before Connection
Knife
Diaphragms

Spring Loaded Seal



Refrigerant Hose

Double-Braided Refrigerant Hose



Double Layer Rayon Cord

Soft Dense Refrigeration Grade Neoprene Inner Liner

Ventilated Outer Core of Tough Heat Resistant Neoprene

Smooth Mandrelled Interior

TUBING
UNIT I

TEST

1. Match the terms on the right to the correct definitions or descriptions.

______a. Rigid copper tubing that should not be bent

______b. Type of tubing used on water lines, drains, and in other applications, but never in connection with refrigerants

______c. Tubing which has been heat treated to soften it for easy bending

______d. Method of soldering tubing

______e. Tubing connector consisting of a nut, sleeve, and union

______f. Fluid carrying pipe which has a thin wall

______g. Enlargement at the end of a piece of tubing which is made at a 45° angle and enables a fitting to be placed on the tubing

______h. Fitting which permits fast and easy connecting and disconnecting of refrigerant lines

______i. Tubing manufactured specifically for air conditioning and refrigeration that is free of contaminants, sealed, and is measured by outside diameter

1. ACR tubing
2. Compression fitting
3. Nominal size tubing
4. Quick connect
5. Annealed tubing
6. Sweat
7. Flare
8. Hard drawn
9. Tube

3. Distinguish between nominal size copper tubing applications and ACR copper tubing applications by placing an "X" for nominal size and an "O" for ACR in the appropriate blank.

______a. Chilled water systems

______b. Refrigerant liquid line

______c. Underground water service where coils are permitted

______d. Hydronic heating where coils are used

______e. Air-conditioning suction line

______f. Severe corrosion conditions

______g. Refrigerant evaporator coils

4. Match the color coding on the right to the type of tubing cartons and tags.

______a. Type M	1. Blue
______b. Type L	2. Yellow
______c. Type K	3. Green
______d. Type DWV	4. Red

5. List the applications of aluminum tubing.

a.

1)

2)

b.

c.

1)

2)

3)

4)

6. List the applications of steel tubing.

   a.

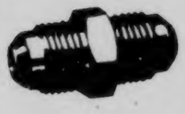
      1)

      2)

      3)

   b.

7. Identify tube and flexible refrigerant hose fittings.



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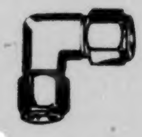

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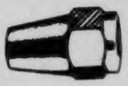

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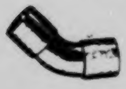

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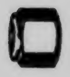

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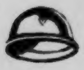

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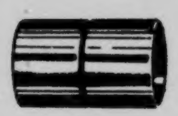

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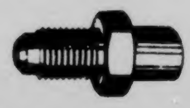

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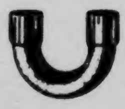

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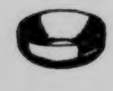

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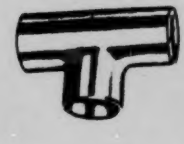

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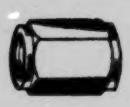

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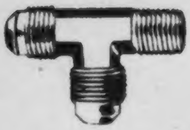

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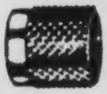

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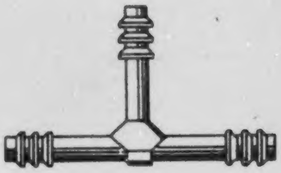

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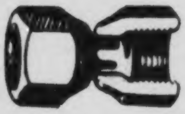

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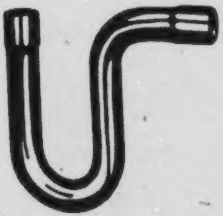

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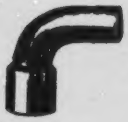
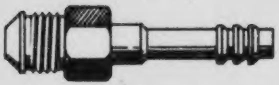
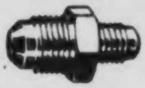


r. ____________________



s. ____________________

t. ____________________



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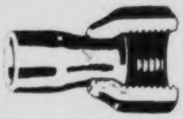

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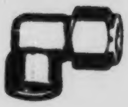

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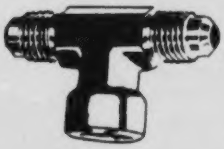

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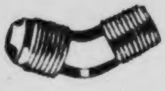

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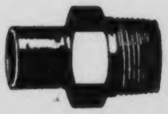

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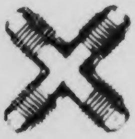

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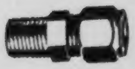

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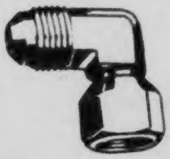

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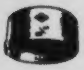

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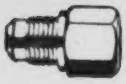

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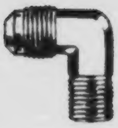

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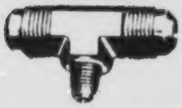

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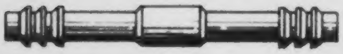

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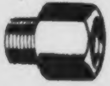

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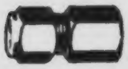

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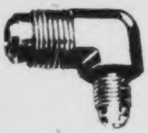

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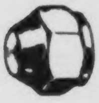

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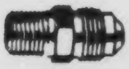

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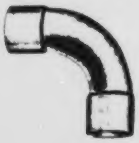

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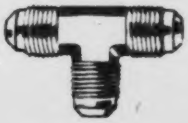

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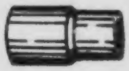

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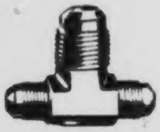

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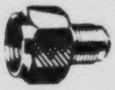

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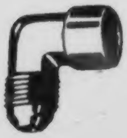

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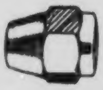

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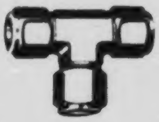

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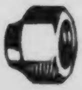

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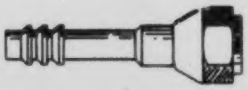

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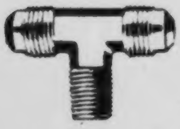

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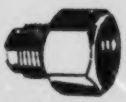

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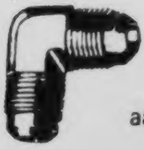

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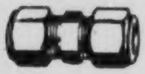

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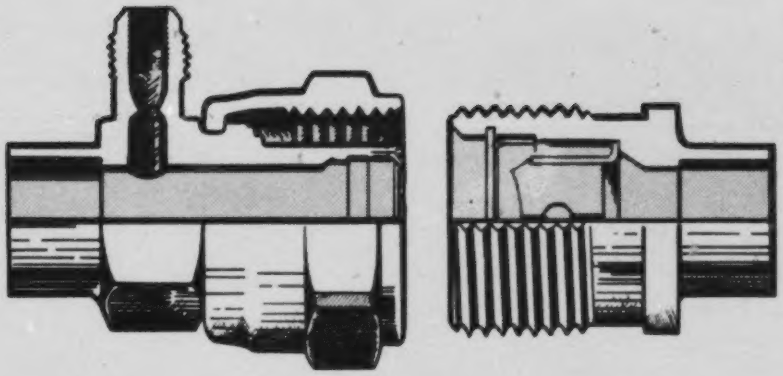

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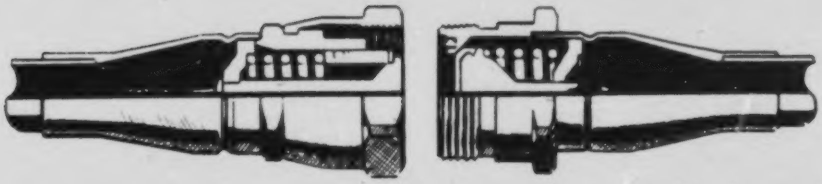


ccc.____

8. Discuss the construction and use of flexible refrigerant hose in this trade.

TUBING
UNIT I

ANSWERS TO TEST

1.
    - a. 8
    - b. 3
    - c. 5
    - d. 6
    - e. 2
    - f. 9
    - g. 7
    - h. 4
    - i. 1
2. Discussion should include:
    - a. Copper
        - 1) Types
            - a) Nominal size
            - b) ACR
        - 2) Temper
            - a) Annealed
            - b) Hard drawn
        - 3) Wall thickness
            - a) K
            - b) L
            - c) M
            - d) DWV
        - 4) Advantages
            - a) High thermal conductivity
            - b) Easy to solder and braze
            - c) Easy to bend and flare
            - d) High resistance to corrosion

b. Aluminum

1) Types

a) Coiled seamless tube

b) Thin wall

2) Contamination prevention

a) Internally cleaned

b) Sealed ends

3) Sizes--5/16" to 3/4" o.d.

4) Advantages

a) High thermal conductivity

b) Easy to bend

c) Easy to flare

5) Disadvantages

a) Porous

b) Easily work hardened

c) Creates corrosive action

6) Connections

a) Aluminum flare nuts

b) Special solder

c) Inert gas welding

d) Epoxy

c. Steel

1) Types

a) Thin wall

b) Stainless

2) Connections

a) Flaring

b) Brazing

3. a. X
   b. O
   c. X
   d. X
   e. O
   f. X
   g. O

4. a. 4
   b. 1
   c. 3
   d. 2

5. a. Domestic refrigerators
      1) Evaporators
      2) Suction lines
   b. Central air-conditioner condenser
   c. Automotive air conditioner
      1) Condenser
      2) Liquid line
      3) Receiver
      4) Evaporator

6. a. Compression refrigeration
      1) Condensers
      2) Liquid lines
      3) Oil coolers
   b. Absorption refrigeration--All refrigerant carrying components must be steel

7. a. Flare union
   b. Compression union elbow
   c. Long flare nut
   d. 45° sweat elbow
   e. Compression nut

f. Flare seal cap

g. Sweat coupling

h. Sweat to flare

i. Return bend

j. Flare gasket

k. Sweat tee

l. Female union

m. Male run tee

n. Flare cap

o. Hose tee splice

p. Flare swivel

q. Suction line trap

r. Sweat street elbow

s. Hose male flare

t. Compression sleeve

u. Reducing union

v. Sweat to flare swivel

w. Compression female elbow

x. Flare tee--Female to male

y. Flare to pipe 45° elbow

z. Sweat to pipe

aa. Flare cross

bb. Compression to pipe union

cc. Female flare elbow

dd. Sweat cap

ee. Flare plug

ff. Flare to pipe elbow

gg. Reducing tee--Small to large

hh. Hose straight splice

ii. Female coupling

jj. Compression female connector

kk. Reducing union elbow

ll. Flare cap

mm. Flare to pipe male connector

nn. Sweat elbow

oo. Flare union tee

pp. Sweat coupling reducer

qq. Reducing tee--Large to small

rr. Reducer

ss. Female elbow

tt. Short flare nut

uu. Compression union tee

vv. Heavy pattern short flare nut

ww. Hose female flare fitting

xx. Flare to pipe branch tee

yy. Female connector

zz. Union elbow

aaa. Compression union

bbb. Quick connect fitting--cutter type

ccc. Quick connect fitting--spring loaded seal

8. Discussion should include:

a. Construction

1) Outer core heat resistant ventilated neoprene

2) Double layer rayon cord

3) Soft dense refrigeration grade neoprene inner liner

b. Use

1) Primarily automotive air conditioning

2) Central air conditioning where complicated bends might be encountered

3) Units that have a tendency to vibrate excessively

TUBING OPERATIONS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to flare, bend, and swage tubing. He should also be able to perform the tubing operations within the design specifications. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with tubing operations to the correct definitions or descriptions.
2. Select the tools needed to construct a copper refrigerant line.
3. Identify the types of flaring blocks.
4. Demonstrate the ability to:
    a. Make a single flare with a compression type flaring block.
    b. Make a single flare with a generating type flaring block.
    c. Make a double flare.
    d. Make a swage joint.
    e. Make a 90° bend.
    f. Make a 180° bend.
    g. Make a 45° offset bend.
    h. Construct a tubing project.

D. Job sheets

1. Job Sheet #1--Make a Single Flare With a Compression Type Flaring Block
2. Job Sheet #2--Make a Single Flare With a Generating Type Flaring Block
3. Job Sheet #3--Make a Double Flare
4. Job Sheet #4--Make a Swage Joint
5. Job Sheet #5--Make a 90° Bend
6. Job Sheet #6--Make a 180° Bend
7. Job Sheet #7--Make a 45° Offset Bend
8. Job Sheet #8--Construct a Tubing Project

E. Test

F. Answers to test

II. References:

A. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Co., 1968.

B. Campbell, Cole G.; Whitman, Elliot R.; and Bell, W. J. *Good Piping Practice.* Des Plains, Illinois: Nickerson and Collins Co., 1972.

TUBING OPERATIONS
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Make transparency.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Show students where a tubing operation has been performed on an actual refrigeration system.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Look around and see how many tubing operations you can identify in the shop and elsewhere.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency master: TM 1--Compression Type and Generating Type Flaring Blocks

TUBING OPERATIONS
UNIT II

INFORMATION SHEET

I. Terms and definitions or descriptions

   A. Single flare--Flare consisting of a single thickness of metal

   B. Double flare--Flare consisting of a double thickness of metal

   (NOTE: Double flares should be used when flaring steel or aluminum.)

   C. Ream--Process of removing the burr inside a piece of tubing after it has been cut

   D. Offset--Portion of the refrigerant line that is set apart from the rest of the refrigerant line

   E. Radius--Distance from the center of an arc or circle to the outside

   F. Wash-out--Thinning of the metal of a flare by overtightening the flaring tool

   (NOTE: This condition will generally result in the flare splitting.)

II. Tools needed to construct a copper refrigerant line

   A. Tubing cutter

   B. Reamer

   C. Flaring block

   D. Flaring tool

III. Types of flaring blocks (Transparency 1)

   A. Compression type

      1. Flare is made down against the chamfer of the block

      2. Overtightening will cause the flare to:

         a. Be oversized

         b. Split

         c. Become work hardened

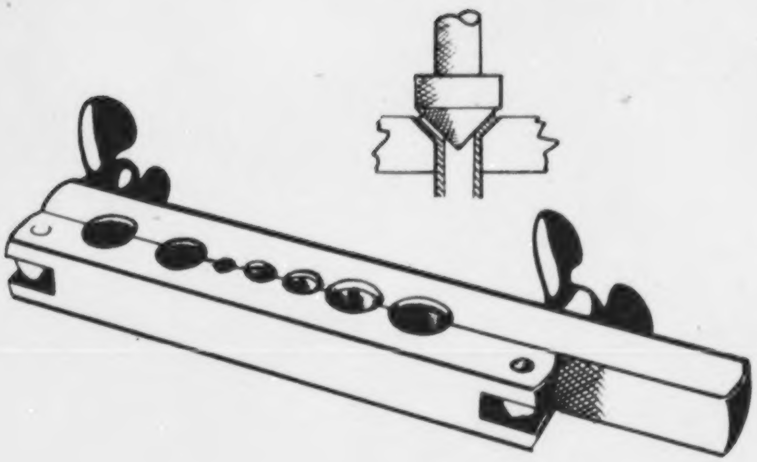
      3. Score marks will appear at the base of the flare

INFORMATION SHEET

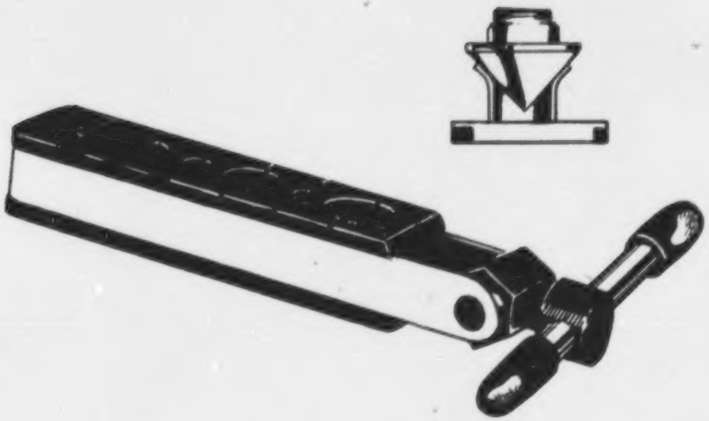
B. Generating type

1. Flare is made above the block
2. Flare should not split due to wash-out
3. No score marks on tubing

Compression Type and Generating Type Flaring Blocks



Compression Type Flaring Block



Generating Type Flaring Block

TUBING OPERATIONS
UNIT II

JOB SHEET #1--MAKE A SINGLE FLARE WITH A COMPRESSION TYPE FLARING BLOCK

I. Tools and materials

  A. Tubing cutter

  B. Reamer

  C. Compression type flaring block

  D. Flaring tool

  E. Tape measure or rule

  F. Refrigeration oil

  G. 3/8" copper tubing (soft rolled)

  H. One 3/8" flare nut

II. Procedure

  A. Unroll a piece of tubing

  B. Measure a 6" piece of copper tubing

  C. Cut tubing

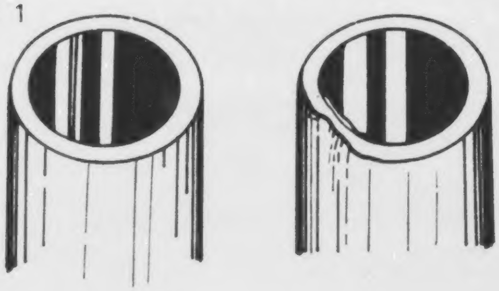
    1. Place cutter on tubing; do not overtighten

    2. Turn a few revolutions and then tighten a little more

    3. Continue to tighten a little bit at a time while turning the cutter

    (NOTE: Cutter should not be so tight that it bends the end of the tubing. See Figure 1.)

FIGURE 1

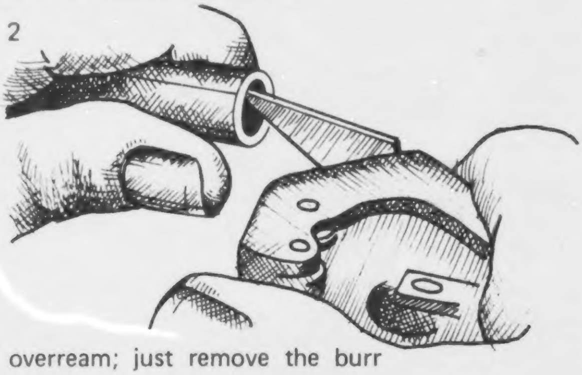


JOB SHEET #1

D. Reseal the end of the roll of tubing

E. Ream the cut piece of tubing (Figure 2)

FIGURE 2

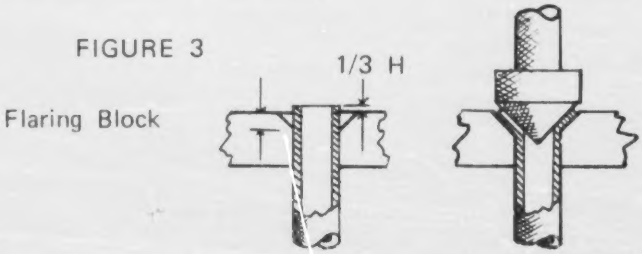


1. Don't overream; just remove the burr
2. Point end of tubing slightly downward while reaming to let chips fall out

F. Place tubing in flaring block

G. Extend tubing above the block 1/3 the depth of the block chamfer (Figure 3)

FIGURE 3



H. Place flaring tool on block

I. Put a drop of refrigeration oil on the threads and a drop on the cone

(Note: Refrigeration oil should always be used when working with refrigeration system components.)

J. Tighten cone into tubing a few turns and then back it out

K. Continue the tightening and then loosening process until the flare is made

(NOTE: This process will tend to make a smooth, polished flare and will lessen the chances of work hardening the tubing.)

JOB SHEET #1

L. Do not overtighten the flaring tool

(NOTE: This will cause the tubing to wash-out and possibly cause the flare to split.)

M. Remove tubing from flaring block

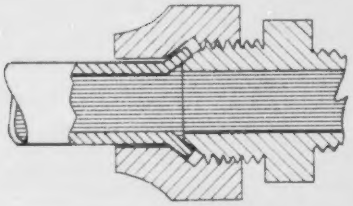
N. Place flare nut on the tubing

O. Check fit of flare in the seat of the flare nut (Figure 4)

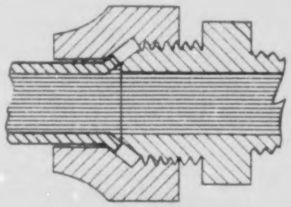
P. Have instructor inspect

Q. Keep tubing for next job sheet

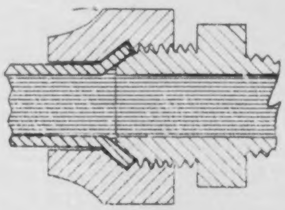
FIGURE 4



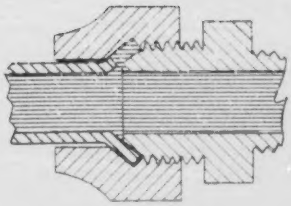
Properly Made Flare



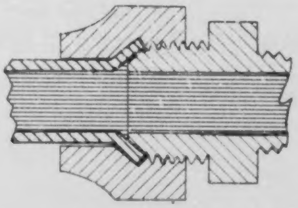
Flare Too Small



Flare Too Large



Flare is Uneven



Tubing was Not Reamed Before Flaring

TUBING OPERATIONS
UNIT II

JOB SHEET #2--MAKE A SINGLE FLARE WITH A GENERATING TYPE FLARING BLOCK

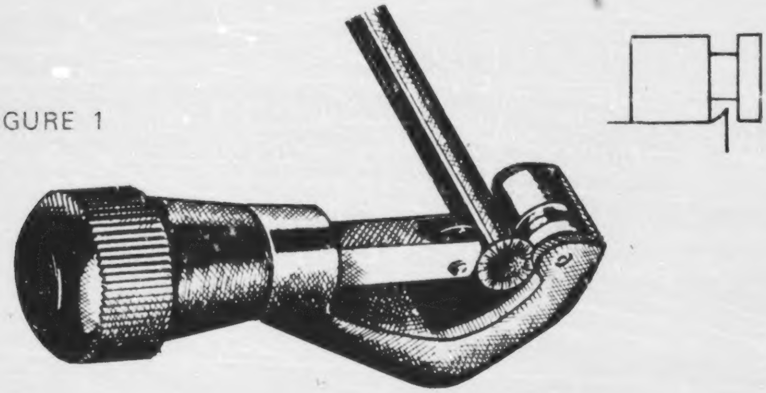
I. Tools and materials

- A. Tubing cutter
- B. Reamer
- C. Generating type flaring block
- D. Flaring tool
- E. Refrigeration oil
- F. 3/8" copper tubing used on Job Sheet #1
- G. 3/8" flare nut used on Job Sheet #1

II. Procedure

- A. Cut off previously made flare
  1. Place flare in slot cutter rollers (Figure 1)

FIGURE 1

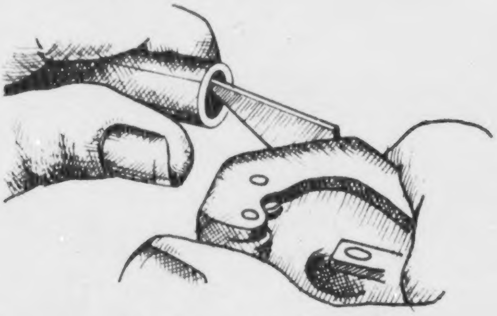


  2. Tighten cutter wheel against the tubing
  3. Turn a few revolutions and then tighten again
  4. Continue this procedure until old flare is cut off

JOB SHEET #2

B. Ream cut piece of tubing (Figure 2)

FIGURE 2



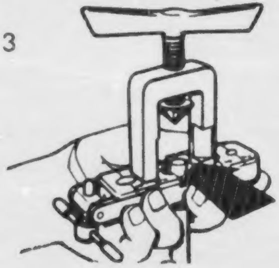
1. Don't overream; just remove the burr

2. Point end of tubing slightly downward while reaming to let chips fall out

C. Place tubing in flaring block

(NOTE: Use the portion of the flaring tool below the slot as a height gauge. See Figure 3.)

FIGURE 3



D. Place flaring tool on block

E. Put a drop of refrigeration oil on the threads and a drop on the cone

F. Tighten the cone into the tubing a few turns and then back it out

G. Continue this process until the flare is made

(NOTE: This process will tend to make a smooth polished flare.)

H. Remove tubing from block

I. Place flare nut on tubing

J. Check fit of flare in the seat of the flare nut

K. Have instructor inspect

L. Keep tubing for next job sheet

TUBING OPERATIONS
UNIT II

JOB SHEET #3--MAKE A DOUBLE FLARE

I. Tools and materials

  A. Tubing cutter

  B. Reamer

  C. Double flare kit

  D. Tape measure

  E. 3/8" o.d. copper tubing

  (NOTE: Use the tubing from Job Sheet #2 if possible.)

II. Procedure

  A. Cut a straight piece of 3/8" o.d. tubing 4" long

    1. Place cutter on tubing; do not overtighten

    2. Turn a few revolutions and then tighten a little more

    3. Continue to tighten a little bit at a time while turning the cutter

    (NOTE: Cutter should not be so tight that it bends the end of the tubing.)

  B. Ream the cut piece of tubing

    1. Don't overream; just remove the burr

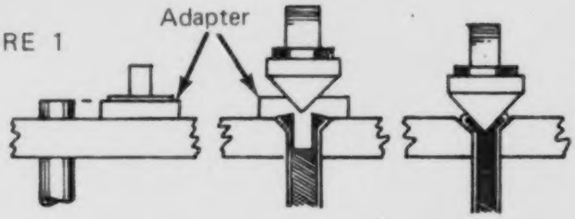
    2. Point end of tubing slightly downward while reaming to let chips fall out

  C. Place tubing in flaring block

JOB SHEET #3

D. Use the double flare adapter as a gauge for the amount of tubing to extend above the block (Figure 1)

FIGURE 1



E. Insert adapter into the end of the tubing

F. Tighten flaring cone down on adapter (Figure 1)

G. Loosen flaring cone

H. Remove adapter

I. Tighten flaring cone into the tubing again (Figure 1)

J. Remove tubing from flaring block

K. Have instructor inspect

L. Keep tubing for next job sheet

TUBING OPERATIONS
UNIT II

JOB SHEET #4--MAKE A SWAGE JOINT

I. Tools and materials

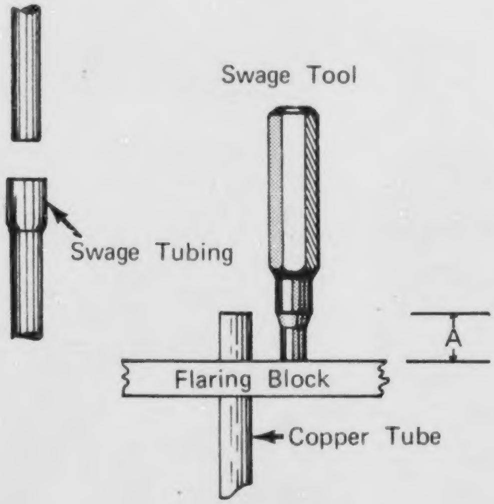
- A. Tubing cutter
- B. Reamer
- C. Flaring block
- D. 3/8" swage punch
- E. Ball peen hammer

II. Procedure

A. Place tubing in block

(NOTE: Tubing must extend above the block the distance of part "A". See Figure 1.)

FIGURE 1


Swage Tool
Swage Tubing
A
Flaring Block
Copper Tube

B. Check the distance by placing the punch adjacent to the tubing (Figure 1)

C. Hold block and tubing in hand

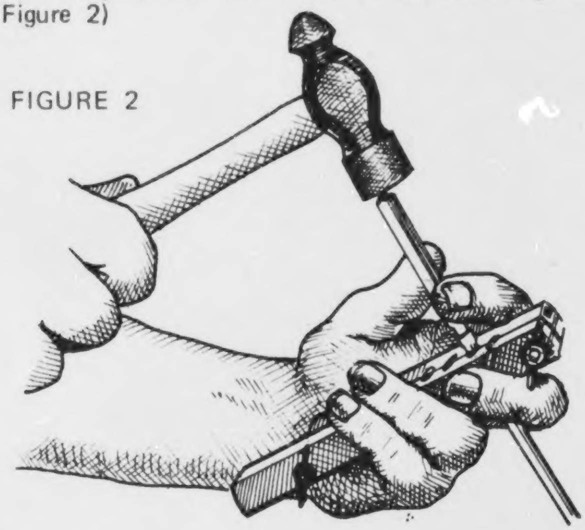
1. Have last two fingers underneath the block

JOB SHEET #4

2. Tubing should be between second and third finger

3. Hold swage punch with thumb and index finger of same hand (Figure 2)

FIGURE 2



D. Lightly tap punch to start it into the tubing

E. Hammer punch on into the tubing

(NOTE: This will create a cup on the end of the tubing.)

(CAUTION: Never hit the punch sideways because this will cause it to break-off.)

F. Remove punch; twisting may be necessary in order to remove it

G. Check to see if 3/8" o.d. tubing will fit into the cup with a close fit

H. Have instructor inspect

I. Keep tubing for use in a later unit

TUBING OPERATIONS
UNIT II

JOB SHEET #5--MAKE A 90° BEND

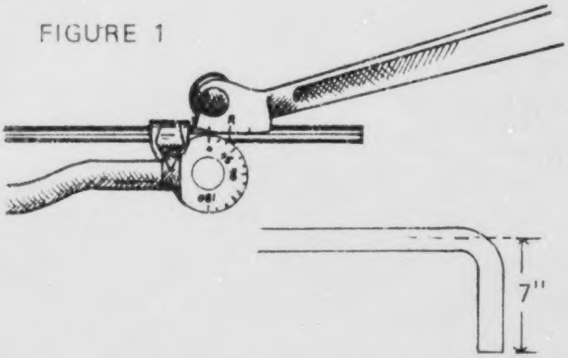
I. Tools and materials

- A. Tubing cutter
- B. 3/8" lever type tubing bender
- C. 3/8" o.d. copper tubing

II. Procedure

- A. Unroll a straight piece of copper tubing
- B. Measure in 17"
- C. Cut off tubing
- D. Place bender on tubing
- E. Measure in 7" on tubing and make a mark
- F. Align "R" mark on bender with mark on tubing (Figure 1)

FIGURE 1



- G. Observe in figure 1 how the bender fits on the tubing
- H. Pull lever until "R" mark aligns with 90° mark on bender
- I. Remove bender
- J. Have instructor inspect
- K. Keep tubing for next job sheet

TUBING OPERATIONS
UNIT II

JOB SHEET #6--MAKE A 180° BEND

I. Tools and materials

   A. Tubing cutter

   B. 3/8" lever type tubing bender

   C. Steel tape

   D. 3/8" o.d. copper tubing

II. Procedure

   A. Unroll a piece of 3/8" o.d. copper tubing and straighten it

   B. Measure a 12" piece of tubing and cut off

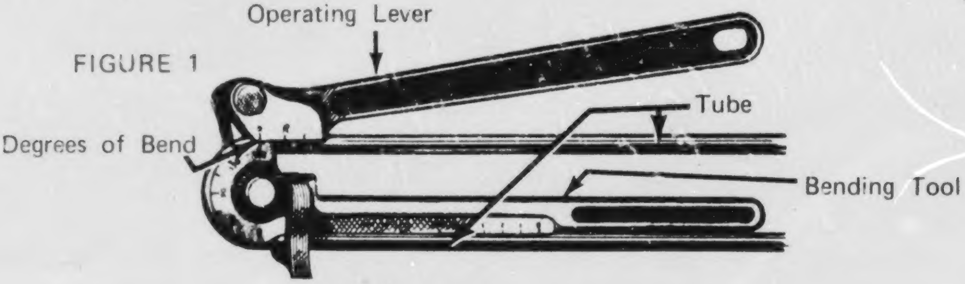
   C. Measure in 4" on tubing and make a mark

   D. Place bender on tube

   E. Align "R" mark on bender with mark on tubing

   F. Pull lever until "R" mark aligns with the 180° mark on bender (Figure 1)

FIGURE 1



   G. Mark the spot on the tubing that aligns with 180° on the bender

   H. Remove bender

   I. Have instructor inspect

TUBING OPERATIONS
UNIT II

JOB SHEET #7--MAKE A 45° OFFSET BEND

I. Tools and materials

   A. Tubing cutter

   B. 3/8" lever type tubing bender

   C. 3/8" o.d. copper tubing

II. Procedure

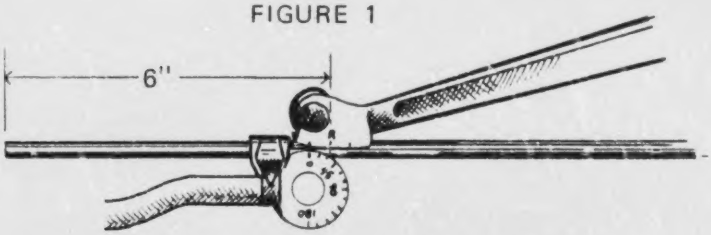
   A. Unroll enough 3/8" o.d. copper tubing to obtain a straight piece 19 1/4" long and cut off

   B. Measure in 6" and make a mark on tubing

   C. Align "R" mark of bender with mark on tubing

   D. Pull lever until "R" mark aligns with 45° mark on bender (Figure 1)

FIGURE 1



   E. Remove bender from tubing

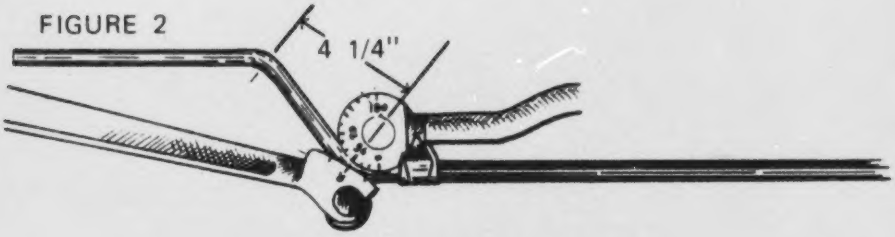
   F. Measure 4 1/4" from first mark and mark the tubing again

JOB SHEET #7

G. Align "R" mark on bender with mark on tubing

(NOTE: Bender must be on opposite side of the tubing from the previous bend. See Figure 2.)

FIGURE 2



H. Pull lever until "R" mark aligns with 45° mark on bender

I. Remove bender from tubing

J. Have instructor inspect

K. Keep tubing for next job sheet

TUBING OPERATIONS
UNIT II

JOB SHEET #8--CONSTRUCT A TUBING PROJECT

I. Tools and materials

- A. Tubing cutter
- B. Reamer
- C. Flaring block
- D. Flaring tool
- E. Swage punch
- F. 3/8" lever type tubing bender
- G. 3/8" o.d. soft copper tubing
- H. 1/4" o.d. soft copper tubing
- I. Two 1/4" flare nuts
- J. One 3/8" sweat tee
- K. One 1/4" sweat tee

II. Procedure

- A. Unroll and measure a piece of 1/4" o.d. copper tubing 6" long
- B. Cut off tubing
- C. Ream tubing
- D. Flare one end
- E. Place flare nut on tubing
- F. Measure down 3" from flare nut and mark tubing
- G. Place bender on tubing
- H. Make a 90° bend

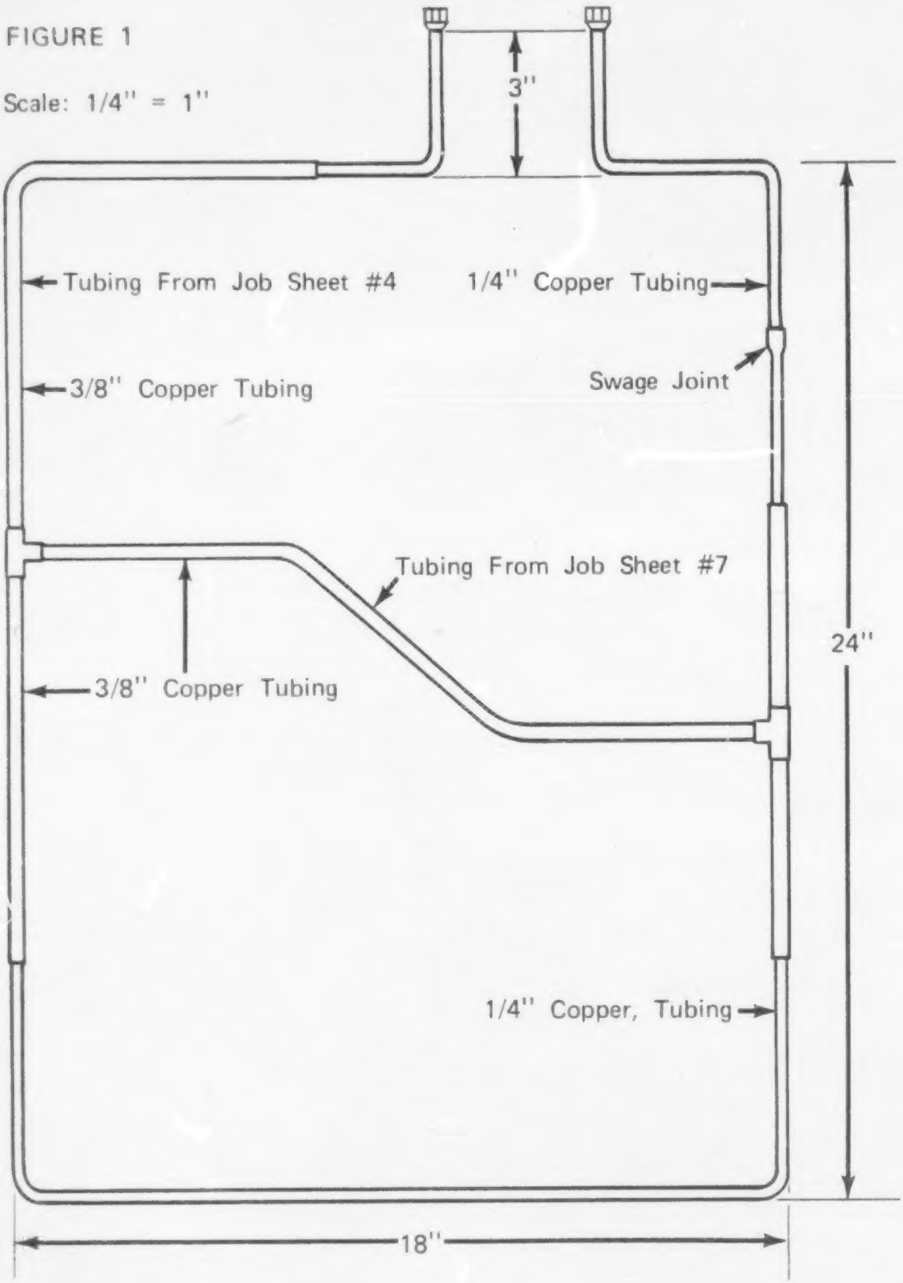
JOB SHEET #8

I. Insert 1/4" tubing into the 3/8" tubing project from Job Sheet #4 (Figure 1)

COPPER TUBING PROJECT

FIGURE 1

Scale: 1/4" = 1"


3"
Tubing From Job Sheet #4
1/4" Copper Tubing
Swage Joint
3/8" Copper Tubing
Tubing From Job Sheet #7
3/8" Copper Tubing
24"
1/4" Copper, Tubing
18"

JOB SHEET #8

J. Insert the other end of 3/8" into a 3/8" sweat tee

K. Cut a straight piece of 3/8" o.d. tubing 8" long

L. Insert one end into tee (Figure 1)

M. Cut a straight piece of 1/4" o.d. tubing 36" long

N. Measure in 9" from both ends and make 90° bend (Figure 1)

O. Cut a piece of straight 3/8" o.d. tubing 5" long

P. Insert one end of the 3/8" x 5" tubing into a sweat tee

Q. Cut a piece of straight 3/8" o.d. tubing 3 1/2" long

R. Insert one end of the 3/8" x 3 1/2" tubing into the sweat tee (Figure 1)

S. Cut a straight piece of 1/4" o.d. tubing 6" long

T. Ream one end

U. Swage the reamed end

V. Cut a straight piece of 1/4" o.d. tubing 14 1/4" long

W. Ream one end

X. Flare the reamed end

Y. Place flare nut on tubing

Z. Measure down 3" from flare nut and mark tubing

AA. Measure down 4 1/2" from the first mark and make another mark

BB. Make two 90° bends (Figure 1)

CC. Place the 45° offset made on Job Sheet #7 between the two tees

DD. Assemble the tubing project

EE. Check the dimensions

FF. Have instructor inspect

GG. Keep tubing project for a later unit

TUBING OPERATIONS
UNIT II

TEST

1. Match the terms on the right to the correct definitions or descriptions.

_____a. Thinning of the metal of a flare by overtightening the flaring tool

_____b. Process of removing the burr inside a piece of tubing after it has been cut

_____c. Flare consisting of a double thickness of metal

_____d. Distance from the center of an arc or circle to the outside

_____e. Flare consisting of a single thickness of metal

_____f. Portion of the refrigerant line that is set apart from the rest of the refrigerant line

1. Offset
2. Double flare
3. Wash-out
4. Radius
5. Single flare
6. Ream

2. Select the tools needed to construct a copper refrigerant line by placing an "X" in the appropriate blank.

_____a. Swage punch

_____b. Flaring block

_____c. Hen-way

_____d. Lever type bender

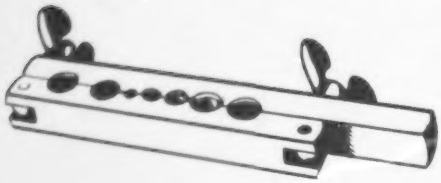
_____e. Flaring tool

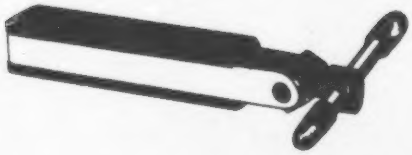
_____f. Reamer

_____g. Tubing crimper

_____h. Tubing cutter

3. Identify the types of flaring blocks.





a. ______________________ b. ______________________

4. Demonstrate the ability to:

a. Make a single flare with a compression type flaring block.

b. Make a single flare with a generating type flaring block.

c. Make a double flare.

d. Make a swage joint.

e. Make a 90° bend.

f. Make a 180° bend.

g. Make a 45° offset bend.

h. Construct a tubing project.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

TUBING OPERATIONS
UNIT II

ANSWERS TO TEST

1. a. 3 d. 4

   b. 6 e. 5

   c. 2 f. 1

2. b, e, f, h

3. a. Compression type

   b. Generating type

4. Performance skills evaluated to the satisfaction of the instructor

PIPE
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to discuss the difference between black iron pipe and galvanized iron pipe. He should also be able to list the advantages and disadvantages of plastic pipe and identify fittings for iron, copper, and P.V.C. pipe. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with pipe to the correct definitions or descriptions.
2. List the types of pipe used in air conditioning and refrigeration.
3. List applications for types of pipe to be used in the air-conditioning and refrigeration trade.
4. Identify iron, brass, flexible plastic, and P.V.C. pipe fittings.
5. Discuss the difference between black iron pipe and galvanized iron pipe.
6. List four advantages and two disadvantages of plastic pipe.
7. Discuss the three common methods of measuring pipe.
8. Select the tools necessary to cut and thread iron pipe.
9. List fourteen steps in cutting and threading iron pipe.
10. Select the tools necessary to make proper P.V.C. joints.
11. List nine steps necessary for installing P.V.C. pipe.
12. Demonstrate the ability to:
    a. Read fitting sizes.
    b. Determine iron pipe lengths and fittings necessary to connect a gas furnace.
    c. Determine lengths of P.V.C. and fittings necessary to construct a condensate line.

PIPE
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and assignment sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information and assignment sheets.

  F. Demonstrate cutting and threading pipe.

  G. Demonstrate cutting and glueing P.V.C.

  H. Demonstrate making a flexible plastic pipe connection.

  I. Have students look up parts in a catalog.

  J. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete assignment sheets.

  D. Look up parts in a catalog to become familiar with how to order parts.

  E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

C. Transparency masters

1. TM 1--Iron Pipe Fittings
2. TM 2--Brass Fittings
3. TM 3--Flexible Plastic Pipe Fittings
4. TM 4--P.V.C. Fittings
5. TM 5--Tools for Cutting and Threading Iron Pipe
6. TM 6--Tools for Making P.V.C. Joints
7. TM 7--Drying Time of P.V.C. Cement

D. Assignment sheets

1. Assignment Sheet #1--Read Fitting Sizes
2. Assignment Sheet #2--Determine Iron Pipe Lengths and Fittings Necessary to Connect a Gas Furnace
3. Assignment Sheet #3--Determine Lengths of P.V.C. and Fittings Necessary to Construct a Condensate Line

E. Answers to assignment sheets

F. Test

G. Answers to test

II. Reference--Slater, Harry. *Related Information Plumbing.* Volume 1 and 2. Albany, New York: Delmar Publishers, 1958.

PIPE
UNIT III

INFORMATION SHEET

I. Terms and definitions or descriptions

A. Galvanize--To coat metal with zinc in order to prevent rusting

(NOTE: Galvanized pipe is not to be used as a natural gas line.)

B. P.V.C.--Rigid plastic pipe

(NOTE: This pipe is generally white in color and P.V.C. is the abbreviation for polyvinyl chloride.)

C. Nipple--Short piece of pipe twelve inches or less in length

D. Gas cock--Manually operated in-line gas valve

E. Flexible plastic pipe--Plastic pipe which comes in a roll and uses slip-in fittings with clamps

(NOTE: This pipe is black in color.)

F. Long pipe--Refers to wrought iron or steel pipe

G. Dope--Thick lead base substance which is applied to pipe threads to help seal the joint

H. F.P.T.--Female pipe taper

I. M.P.T.--Male pipe taper

J. Cast fittings--Heavy steel pipe fittings that are formed in a mold

(NOTE: These fittings are generally referred to as malleable iron fittings.)

II. Pipe used in air conditioning and refrigeration

A. Iron

1. Black

2. Galvanized

B. Flexible plastic

INFORMATION SHEET

C. P.V.C.

D. Copper

(NOTE: Copper pipe is usually referred to as tubing.)

III. Pipe applications in the air-conditioning and refrigeration trade

A. Black iron pipe

1. Natural gas lines to furnaces
2. Liquified petroleum gas lines to furnaces
3. Ammonia lines

B. Galvanized iron pipe

1. Ice maker water lines
2. Chilled water lines
3. Water cooled condenser supply and return lines
4. Condensate lines

C. Plastic pipe

(NOTE: This includes both P.V.C. and flexible plastic pipe.)

1. Water supply lines
2. Underground gas lines
3. Condensate lines
4. Chilled water supply and return lines

(NOTE: Local codes should be checked before using plastic pipe.)

IV. Pipe fittings (Transparency 1)

A. Iron fittings

(NOTE: Iron fittings are used on black iron and galvanized iron pipe.)

1. 90° ell
2. Tee

INFORMATION SHEET

3. 45° ell
4. 90° street ell
5. Union

   (NOTE: When connecting galvanized pipe to any other type of pipe, a special union must be used to prevent a corrosive action. This union is called an insulated union.)

6. Coupling
7. Reducer
8. Flange
9. Bushing
10. Cap
11. Plug
12. Nipple
13. Gas cock

B. Brass fittings (Transparency 2)

(NOTE: Brass fittings are used on copper pipe.)

1. Nipple
2. 90° ell
3. Street ell
4. Tee
5. Male pipe to male flare
6. Female pipe to male flare
7. Flexible gas connector
8. Plug
9. Bushing

INFORMATION SHEET

10. Two-way shut-off valve
11. Three-way shut-off valve
12. Saddle valve

C. Flexible plastic fittings (Transparency 3)

(NOTE: Flexible plastic pipe fittings are used on flexible plastic pipe.)

1. Insert tee
2. Insert 90° ell
3. Insert male adapter
4. Insert male steel adapter
5. Insert coupling
6. Clamp

D. P.V.C. fittings (Transparency 4)

(NOTE: P.V.C. fittings are used on P.V.C. pipe.)

1. 90° ell
2. 45° ell
3. Tee
4. Male adapter
5. Female adapter
6. Coupling
7. Bushing
8. Cap
9. 90° ell (P.V.C. to pipe)

INFORMATION SHEET

V. Black iron pipe and galvanized iron pipe

   A. Black iron pipe

      1. Painted black

         (NOTE: The black paint aids in the prevention of rust and helps to distinguish it from galvanized pipe.)

      2. Uses

         a. Gas lines

         b. Compressed air lines

         c. Chilled liquid lines

         d. Hydronic heat

         e. Steam lines

   B. Galvanized iron pipe

      1. Coated to resist rusting

      2. Uses

         a. Water pipe

         b. Condensate drains

VI. Advantages and disadvantages of plastic pipe

   A. Advantages

      1. Lightweight

      2. Resists corrosion and electrolysis

      3. Good for long runs underground

      4. May be bent

   B. Disadvantages

      1. Will not withstand temperatures over 150°F

      2. Not stable at pressures over 100 lbs. p.s.i.

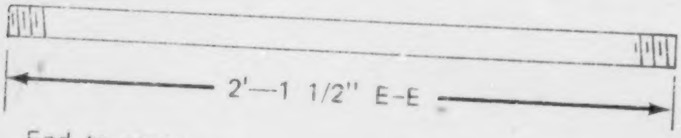
INFORMATION SHEET

VII. Methods of measuring pipe

A. End to end

1. Straight length of pipe
2. Measure pipe without fittings (Figure 1)

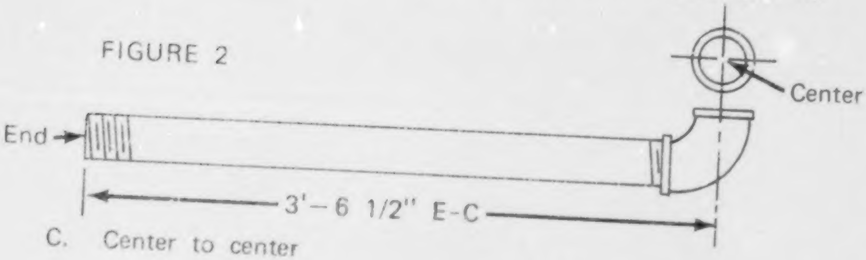
FIGURE 1



B. End to center

1. Straight length of pipe
2. Tighten a fitting on one end
3. Measure from end to center of fitting (Figure 2)

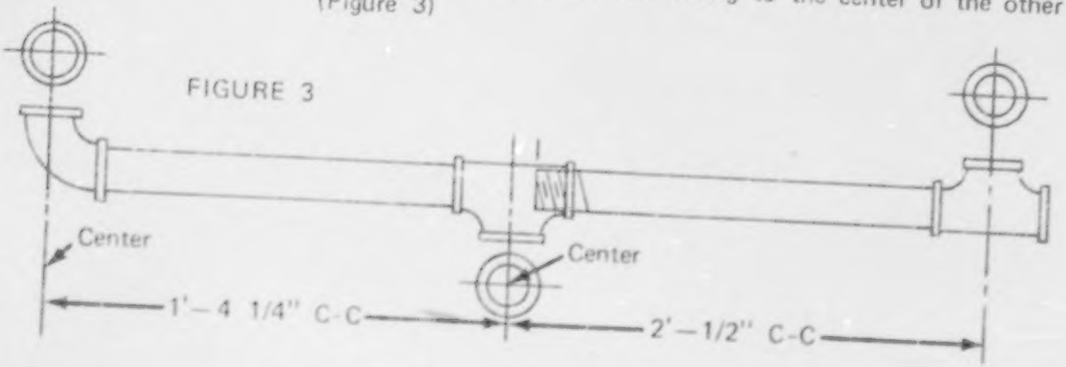
FIGURE 2


Center
End
3'– 6 1/2" E-C

C. Center to center

1. Straight length of pipe
2. Tightened fitting on each end
3. Measure from center of one fitting to the center of the other (Figure 3)

FIGURE 3


Center
Center
1'– 4 1/4" C-C
2'– 1/2" C-C

INFORMATION SHEET

VIII. Tools necessary to cut and thread iron pipe (Transparency 5)

  A. Cutter

  B. Reamer

  C. Pipe vise

  D. Dies

  E. Die stock

  F. Oil can

IX. Cutting and threading iron pipe

  A. Secure pipe in vise

  B. Cut the pipe

  (NOTE: Cut end must be square.)

  C. Ream inside of pipe to remove burrs

  D. Lightly file outside cut edge

  E. Inspect and clean dies before threading

  F. Check cutting edges for sharpness

  G. Be sure dies are in the die stock properly

  H. Center die on pipe

  I. Turn die slowly in a clockwise direction

  J. Apply cutting oil while threading

  (NOTE: A good grade of cutting oil eases cutting and cools die threads.)

  K. Determine length of the threaded portion

  (NOTE: This can be determined by using Table 1.)

INFORMATION SHEET

TABLE 1

SPECIFICATIONS FOR THREADING PIPE

Nominal Size of Pipe in Inches	Approx. Length of Threads in Inches	Approx. Number of Threads To Be Cut
1/2	3/4	10
3/4	3/4	10
1	7/8	10
1 1/4	1	11
1 1/2	1	11
2	1	11
2 1/2	1 1/2	12
3	1 1/2	12
4	1 2/3	13

L. Remove die by turning counterclockwise

M. Clean chips from threads

N. Clean chips from dies

(CAUTION: Do not remove chips with compressed air.)

X. Tools necessary for proper P.V.C. joints (Transparency 6)

A. Miter box

B. Miter saw

C. Clean towels

D. P.V.C. cleaner

E. Knife

F. P.V.C. cement

G. Natural bristle or nylon brush

INFORMATION SHEET

XI. Steps for installing P.V.C. pipe

A. Cut pipe square

B. Remove burrs inside and out

C. Clean pipe with clean towel

D. Check fit of pipe into fitting

E. Clean pipe with P.V.C. cleaner

F. Apply a coat of cement with brush

G. Put fitting on pipe immediately after applying cement

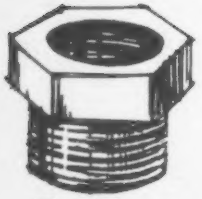
(NOTE: Fitting must be turned in the proper direction when it is placed on the pipe because it can not be moved once it comes into contact with the cement.)

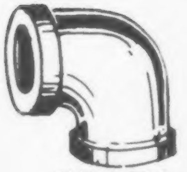
H. Hold pressure against fitting momentarily

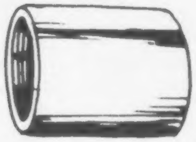
I. Don't disturb pipe until dry (Transparency 7)

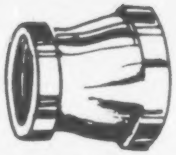
(NOTE: Drying time is dependent on the ambient temperature.)

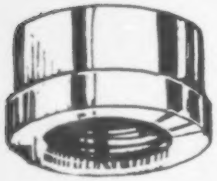
Iron Pipe Fittings

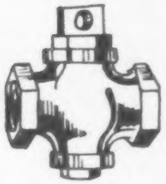

Bushing

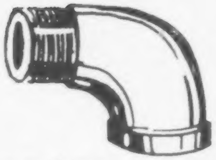

90° Ell

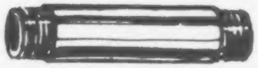

Coupling

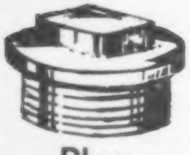

Reducer

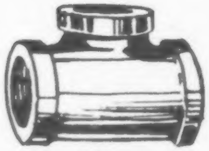

Cap

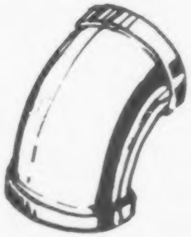

Gas Cock

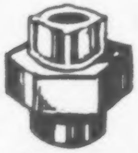

90° Street Ell

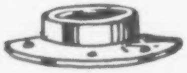

Nipple


Plug

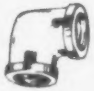

Tee

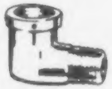

45° Ell

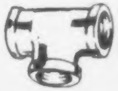

Union

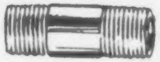

Flange

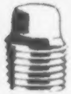
Brass Fittings

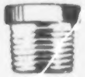

90° Ell

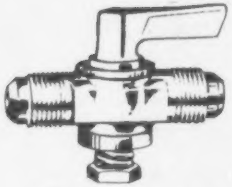

Street Ell

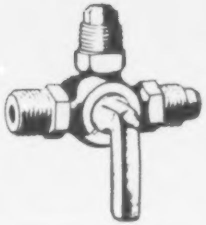

Tee

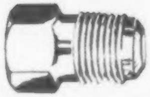

Nipple

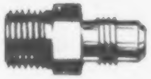

Plug

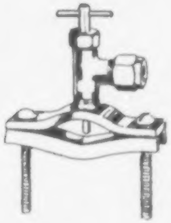

Bushing

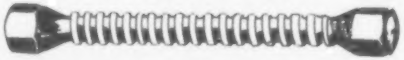

Two-Way Shut-Off Valve


Three-Way Shut-Off Valve

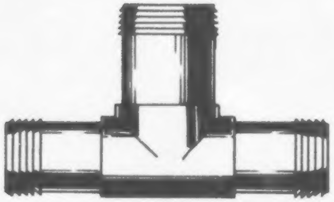

Female Pipe To Male Flare


Male Pipe To Male Flare

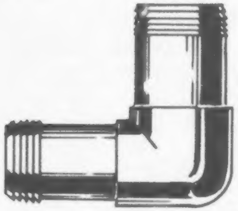

Saddle Valve


Flexible Gas Connector

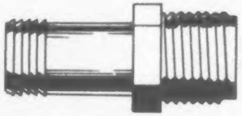
Flexible Plastic Pipe Fittings



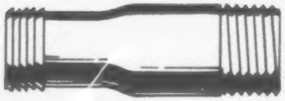
Insert Tee



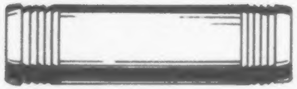
Insert 90° Ell



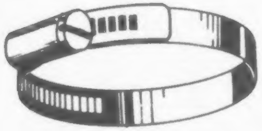
Insert Male Adapter



Insert Male
Steel Adapter

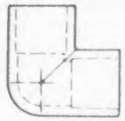


Insert Coupling

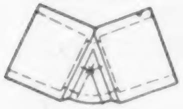


Clamp

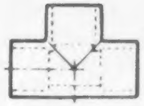
P.V.C. Fittings



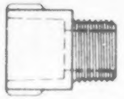
90° ELL



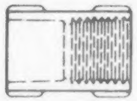
45° EL



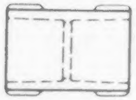
Tee



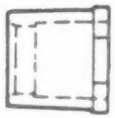
Male Adapter



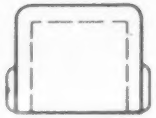
Female Adapter



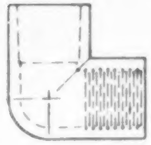
Coupling



Bushing

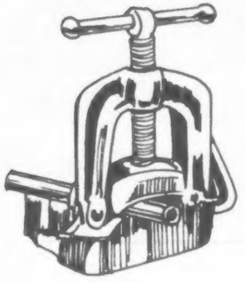


Cap

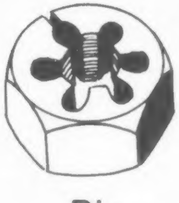


90° EL
P.V.C. to Pipe

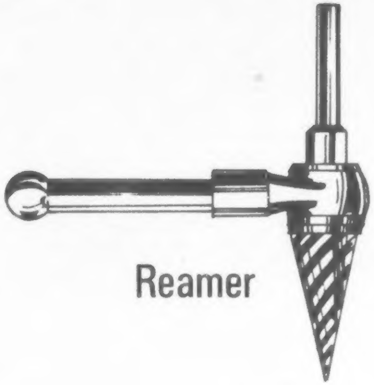
Tools For Cutting and Threading Iron Pipe



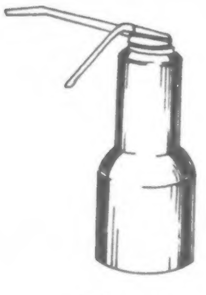
Pipe Vise



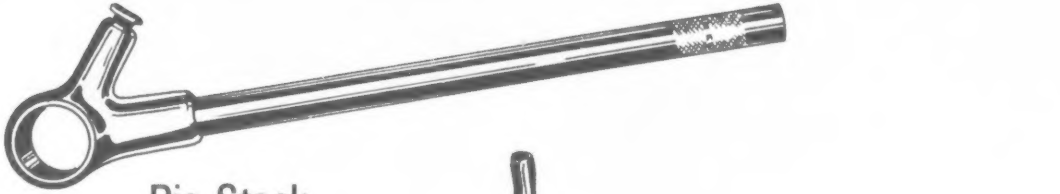
Die



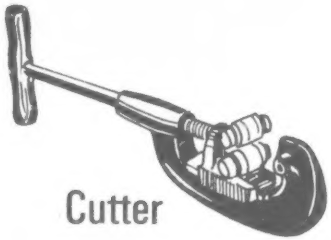
Reamer



Oil Can

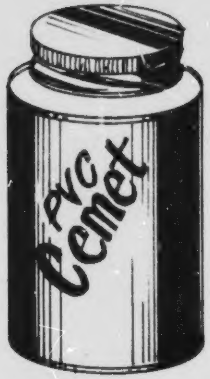


Die Stock

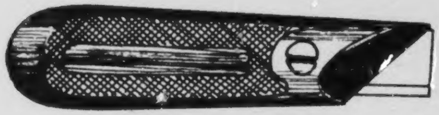


Cutter

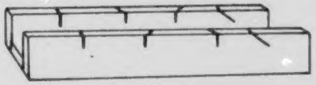
Tools For Making P.V.C. Joints



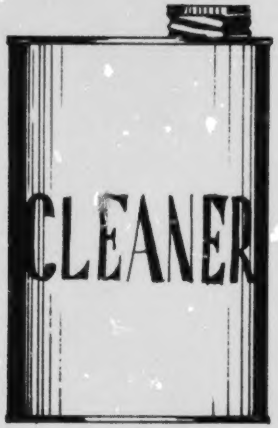
P.V.C. Cement



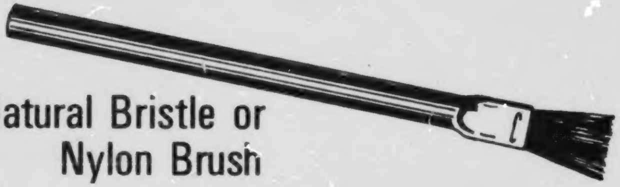
Knife



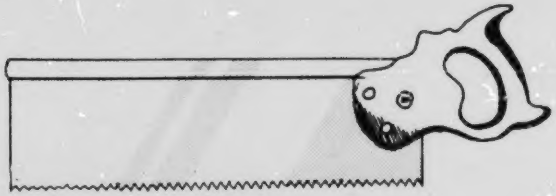
Miter Box



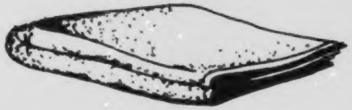
P.V.C. Cleaner



Natural Bristle or
Nylon Brush

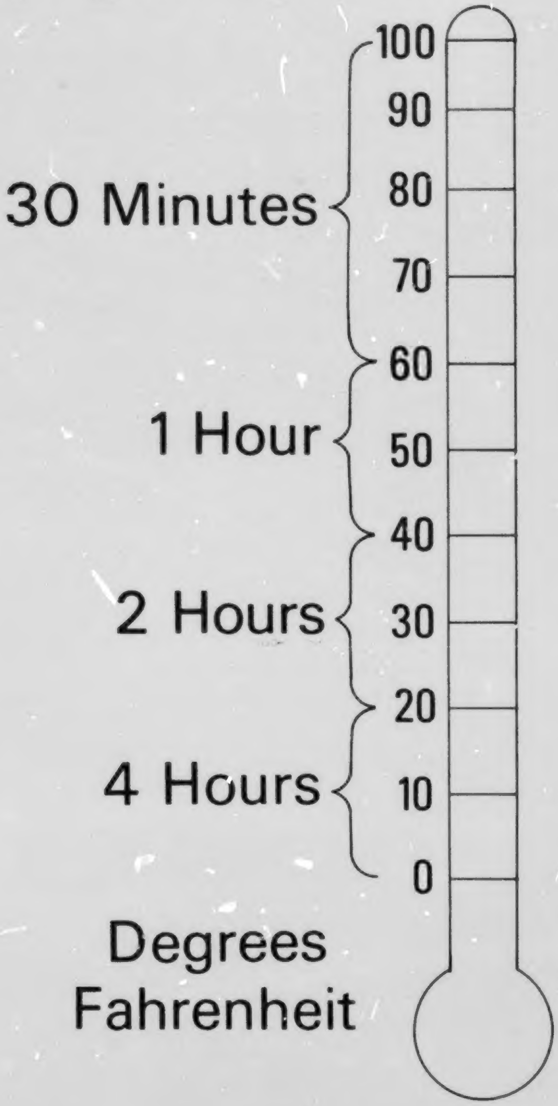


Miter Saw



Clean Towels

Drying Time of P.V.C. Cement


100
90
30 Minutes
80
70
60
1 Hour
50
40
2 Hours
30
20
4 Hours
10
0
Degrees
Fahrenheit

PIPE
UNIT III

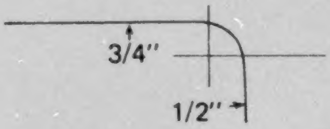
ASSIGNMENT SHEET #1--READ FITTING SIZES

Ells, street ells, and tees are available in reducing sizes. When ordering a reducing fitting, give the larger size first.

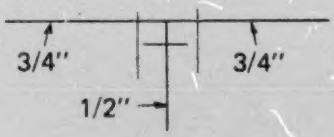
Example: To connect two pieces of 1/2" pipe to a 3/4" line it would take a 3/4" x 1/2" x 1/2" tee

Give the fitting type and size in proper order for the following.

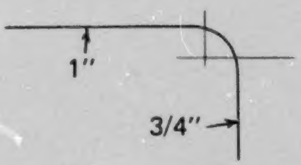
1. A 3/4" line must make a 90° turn and then connect into a 1/2" line.



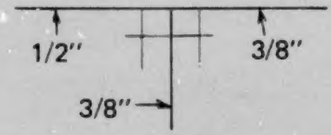
2. A 1/2" gas line needs to be connected to a 3/4" gas line and 3/4" line will go on straight. The 1/2" line will be perpendicular to the 3/4" line.



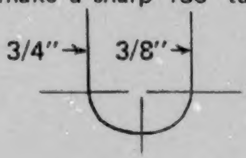
3. A 1" water line needs to make a 90° turn and connect into a 3/4" female fitting.



4. A 1/2" supply air line needs to branch off to two 3/8" air lines.



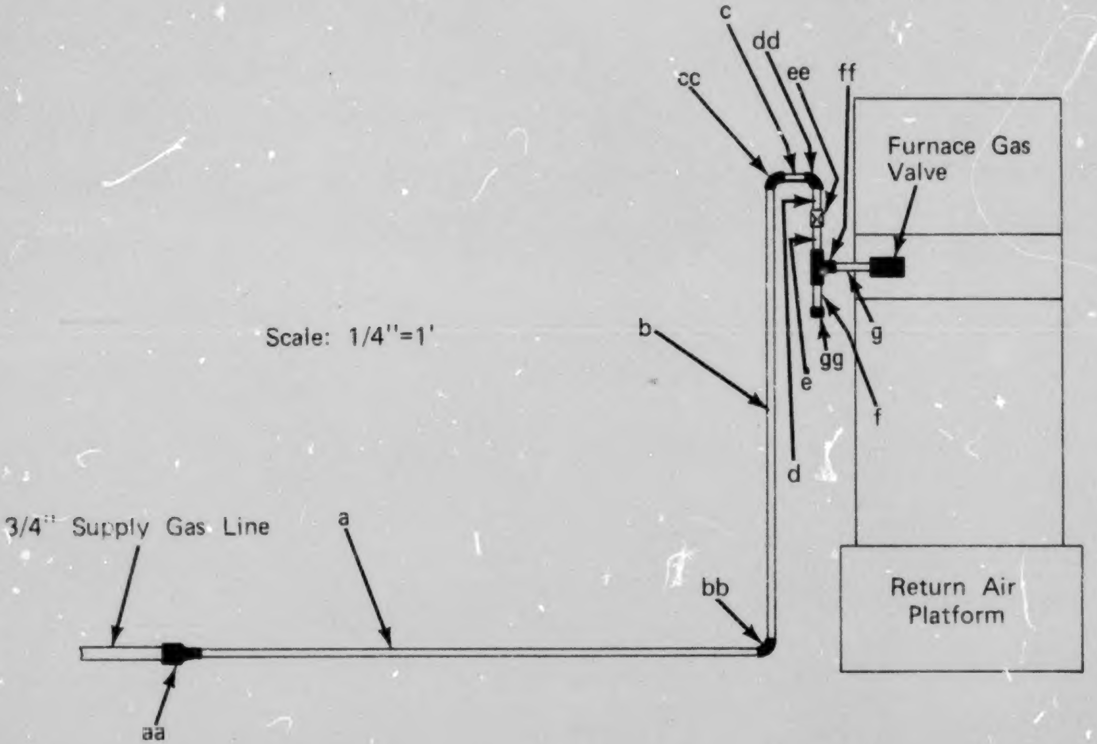
5. A 3/4" water line must make a sharp 180° turn and connect onto a 3/8" line.



PIPE
UNIT III

ASSIGNMENT SHEET #2--DETERMINE IRON PIPE LENGTHS AND FITTINGS NECESSARY TO CONNECT A GAS FURNACE

Make a list of the pipe length and the fittings necessary to connect the gas furnace below to the supply gas line. Place a gas cock in the line prior to where the line enters the furnace cabinet. Gas valve has 1/2" female pipe inlet.


c
dd
cc
ee
ff
Furnace Gas Valve
Scale: 1/4"=1'
b
e
gg
g
f
d
3/4" Supply Gas Line
a
bb
Return Air Platform
aa

ASSIGNMENT SHEET #2

Pipe length

a

b

c

d

e

f

g

Fitting Size

aa

bb

cc

dd

ee

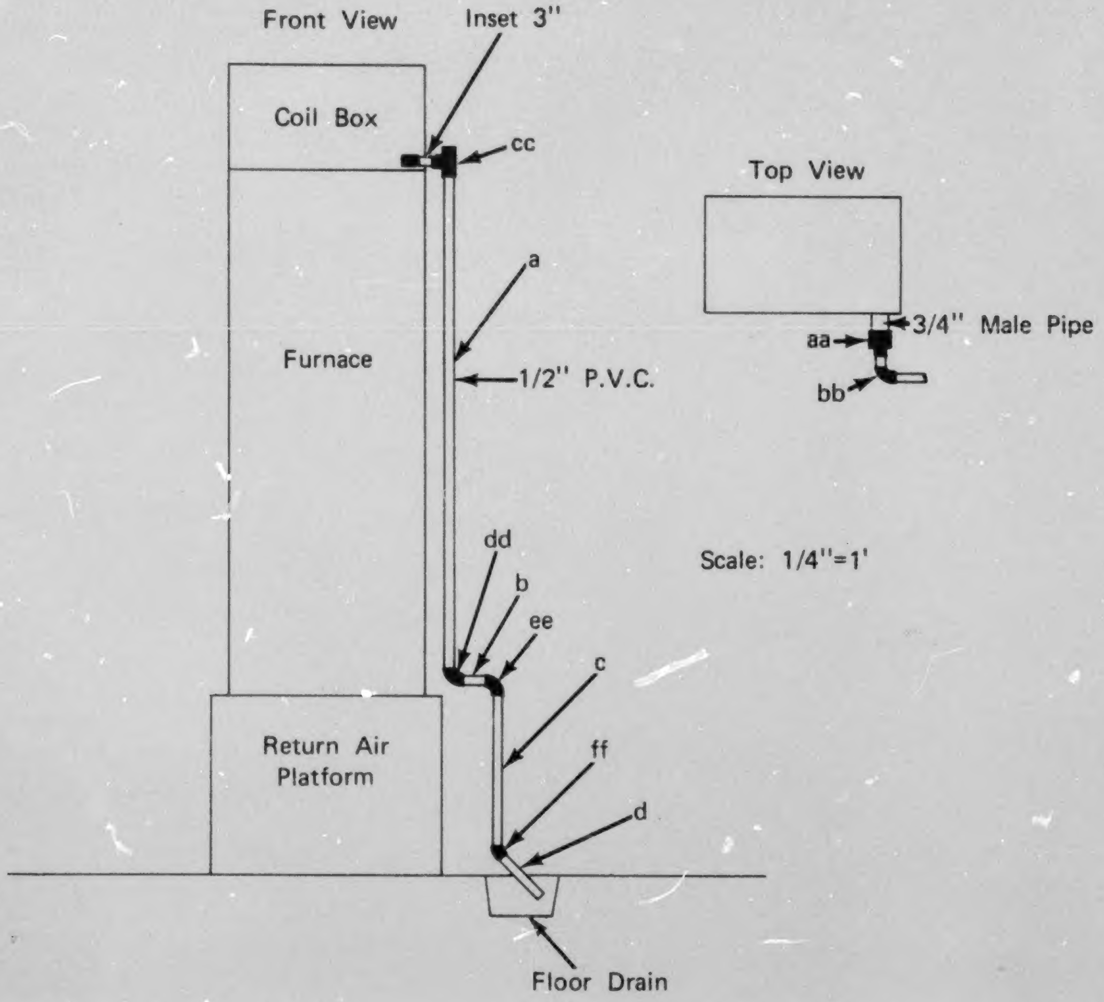
ff

gg

PIPE
UNIT III

ASSIGNMENT SHEET #3--DETERMINE LENGTHS OF P.V.C. AND FITTINGS NECESSARY TO CONSTRUCT A CONDENSATE LINE

Make a list of the lengths of P.V.C. and fittings necessary to construct the condensate line on the system below. Condensate drain on coil is 3/4" male pipe and comes straight out of coil box. Front of coil box sets back six inches which allows room for making connections.


Front View
Inset 3"
Coil Box
cc
Furnace
a
1/2" P.V.C.
dd
b
ee
c
ff
d
Return Air Platform
Floor Drain
Top View
3/4" Male Pipe
aa
bb
Scale: 1/4"=1'

ASSIGNMENT SHEET #3

P.V.C. lengths

a

b

c

d

Fittings

Fitting (aa) connects to coil condensate drain.

Fitting (bb) enables the drain line to turn in a direction parallel to the top of the furnace.

aa

bb

cc

dd

ee

ff

PIPE
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. Black iron pipe, 3/4" x 1/2" ell
2. Black iron pipe, 3/4" x 3/4" x 1/2" tee
3. Galvanized iron pipe, 1" x 3/4" street ell
4. Black iron pipe, 1/2" x 3/8" x 3/8" tee
5. Galvanized iron pipe, 3/4" x 1/2" street ell, 1/2" x 3/8" ell

Assignment Sheet #2

a. 13'
b. 10' 6"
c. 6"
d. 6"
e. 6"
f. 6"
g. 9"

aa. 3/4" x 1/2" reducer
bb. 1/2" ell
cc. 1/2" ell
dd. 1/2" ell
ee. 1/2" gas cock
ff. 1/2" tee
gg. 1/2" cap

Assignment Sheet #3

a. 11' 6"
b. 6"
c. 3' 6"
d. 1' 3"

aa. 3/4" F.P.T. to 1/2"
bb. 1/2" ell
cc. 1/2" tee
dd. 1/2" ell
ee. 1/2" ell
ff. 1/2" 45° ell

PIPE
UNIT III

TEST

1. Match the terms on the right to the correct definitions or descriptions.

_____a. Rigid plastic pipe

_____b. Manually operated in-line gas valve

_____c. To coat metal with zinc in order to prevent rusting

_____d. Short piece of pipe twelve inches or less in length

_____e. Plastic pipe which comes in a roll and uses slip-in fittings with clamps

_____f. Heavy steel pipe fittings that are formed in a mold

_____g. Thick lead base substance which is applied to pipe threads to help seal the joint

_____h. Female pipe taper

_____i. Refers to wrought iron or steel pipe

_____j. Male pipe taper

1. Long pipe
2. Gas cock
3. Nipple
4. Dope
5. P.V.C.
6. Galvanize
7. Flexible plastic pipe
8. M.P.T.
9. F.P.T.
10. Cast fittings

2. List the types of pipe used in air conditioning and refrigeration.

a.

1)

2)

b.

c.

d.

3. List two applications for each type of pipe to be used in the air-conditioning and refrigeration trade.

   a. Black iron pipe

      1)

      2)

   b. Galvanized iron pipe

      1)

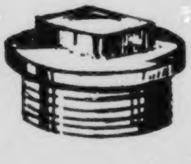
      2)

   c. Plastic pipe

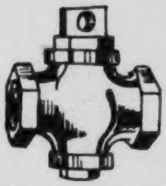
      1)

      2)

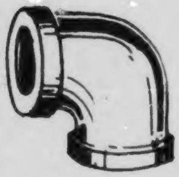
4. Identify the iron, brass, flexible plastic, and P.V.C. pipe fittings.



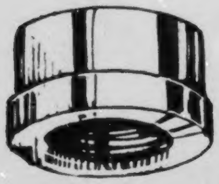
a. ______________



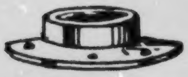
b. ______________



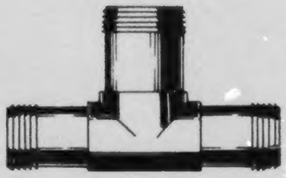
c. ______________



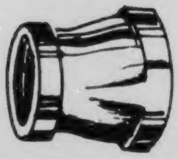
d. ______________



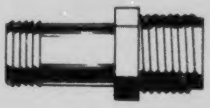
e. ______________



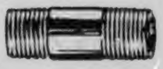
f. ______________



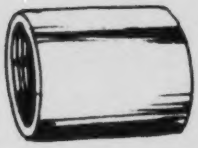
g. ______________



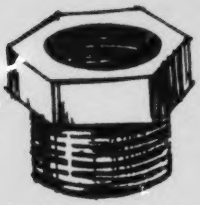
h. ______________



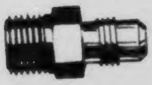
i. ______________



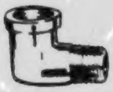
j. ____________



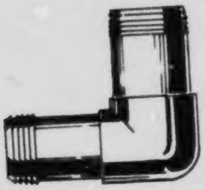
k. ____________



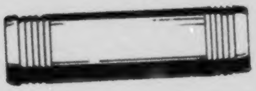
l. ____________



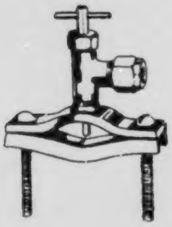
m. ____________



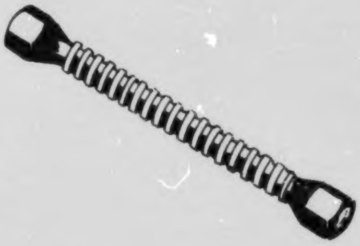
n. ____________



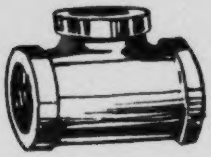
o. ____________



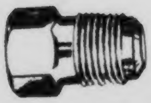
p. ____________



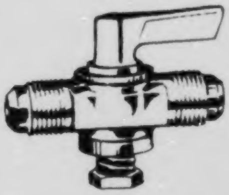
q. ____________



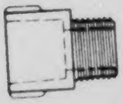
r. ____________



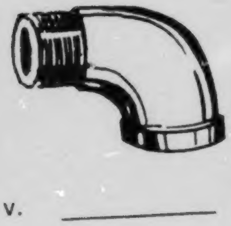
s. ____________



t. ____________



u. ____________



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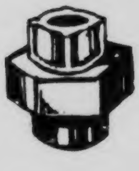

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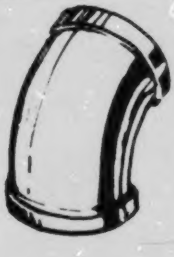

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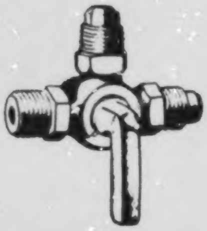

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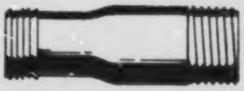

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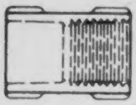

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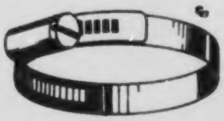

bb. ____________________

5. Discuss the difference between black iron pipe and galvanized iron pipe.

6. List four advantages and two disadvantages of plastic pipe.

   a. Advantages

      1)

      2)

      3)

      4)

b. Disadvantages

1)

2)

7. Discuss the three common methods of measuring pipe.

8. Select the tools necessary to cut and thread iron pipe by placing an "X" in the appropriate blank.

_____a. Pipe vise

_____b. Oil can

_____c. Pipe wrench

_____d. Reamer

_____e. Cutter

_____f. Die stock

_____g. Flaring tool

_____h. Dies

9. List fourteen steps in cutting and threading iron pipe.

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

k.

l.

m.

n.

10. Select the tools necessary to make proper P.V.C. joints by placing an "X" in the appropriate blank.

______a. Pipe vise

______b. Knife

______c. Miter saw

______d. P.V.C. cement

______e. Hammer

______f. Natural bristle or nylon brush

______g. Pipe wrench

______h. Miter box

______i. Clean towels

11. List nine steps necessary for installing P.V.C. pipe.

a.

b.

c.

d.

e.

f.

g.

h.

i.

12. Demonstrate the ability to:

    a. Read fitting sizes.

    b. Determine iron pipe lengths and fittings necessary to connect a gas furnace.

    c. Determine lengths of P.V.C. and fittings necessary to construct a condensate line.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

PIPE
UNIT III

ANSWERS TO TEST

1. a. 5
   b. 2
   c. 6
   d. 3
   e. 7
   f. 10
   g. 4
   h. 9
   i. 1
   j. 8
2. a. Iron
      1) Black
      2) Galvanized
   b. Flexible plastic
   c. P.V.C.
   d. Copper
3. Any two of the following under each type of pipe:
   a. Black iron pipe
      1) Natural gas lines to furnaces
      2) Liquified petroleum gas lines to furnaces
      3) Ammonia lines
   b. Galvanized iron pipe
      1) Ice maker water lines
      2) Chilled water lines
      3) Water cooled condenser supply and return lines
      4) Condensate lines
   c. Plastic pipe
      1) Water supply lines

2) Underground gas lines

3) Condensate lines

4) Chilled water supply and return lines

4. a. Plug

b. Gas cock

c. 90° ell

d. Cap

e. Flange

f. Insert tee

g. Reducer

h. Insert male adapter

i. Nipple

j. Coupling

k. Bushing

l. Male pipe to male flare

m. Street ell

n. Insert 90° ell

o. Insert coupling

p. Saddle valve

q. Flexible gas connector

r. Tee

s. Female pipe to male flare

t. Two-way shut-off valve

u. Male adapter

v. 90° street ell

w. Union

- x. 45° ell
- y. Three-way shut-off valve
- z. Insert male steel adapter
- aa. Female adapter
- bb. Clamp

5. Discussion should include:
    - a. Black iron pipe
        - 1) Painted black
        - 2) Uses
            - a) Gas lines
            - b) Compressed air lines
            - c) Chilled liquid lines
            - d) Hydronic heat
            - e) Steam lines
    - b. Galvanized iron pipe
        - 1) Coated to resist rusting
        - 2) Uses
            - a) Water pipe
            - b) Condensate drains

6. a. Advantages
    - 1) Lightweight
    - 2) Resists corrosion and electrolysis
    - 3) Good for long runs underground
    - 4) May be bent
    - b. Disadvantages
        - 1) Will not withstand temperatures over 150°F
        - 2) Not stable at pressures over 100 lbs. p.s.i.

7. Discussion should include:
    a. End to end
        1) Straight length of pipe
        2) Measure pipe without fittings
    b. End to center
        1) Straight length of pipe
        2) Tighten a fitting on one end
        3) Measure from end to center of fitting
    c. Center to center
        1) Straight length of pipe
        2) Tightened fitting on each end
        3) Measure from center of one fitting to the center of the other

8. a, b, d, e, f, h

9. a. Secure pipe in vise
    b. Cut the pipe
    c. Ream inside of pipe to remove burrs
    d. Lightly file outside cut edge
    e. Inspect and clean dies before threading
    f. Check cutting edges for sharpness
    g. Be sure dies are in the die stock properly
    h. Center die on pipe
    i. Turn die slowly in a clockwise direction
    j. Apply cutting oil while threading
    k. Determine length of the threaded portion
    l. Remove die by turning counterclockwise
    m. Clean chips from threads
    n. Clean chips from dies

10. b, c, d, f, h, i

11.
    a. Cut pipe square
    b. Remove burrs inside and out
    c. Clean pipe with clean towel
    d. Check fit of pipe into fitting
    e. Clean pipe with P.V.C. cleaner
    f. Apply a coat of cement with brush
    g. Put fitting on pipe immediately after applying cement
    h. Hold pressure against fitting momentarily
    i. Don't disturb pipe until dry

12. Evaluated to the satisfaction of the instructor

PROGRESS CHART

Tubing and Pipe

Date

Air Conditioning and Refrigeration

Section D

What The Trainee Should Be Able To Do

Names	Identify fittings		Make a single flare With a compression Type flaring block				Make a single flare With a generating Type flaring block				Make a double flare		Make a swage joint		Make a 90° bend		Make a 180° bend		Make a 45° offset bend		Construct a tubing project		Read fitting sizes		Determine iron pipe lengths and fittings necessary to connect a gas furnace				Determine lengths of P.V.C. and fittings necessary to construct a condensate line																
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PROGRESS CHART

Tubing and Pipe

Date ____________________

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1												
2												
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SOLDERING AND WELDING EQUIPMENT
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to use and care for the air-acetylene torch, oxyacetylene torch, and the electric welder. He should also be able to identify the components of the air-propane torch and select safety rules pertaining to soldering and welding. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with soldering and welding equipment to the correct definitions.
2. Select safety rules for using soldering and welding equipment.
3. Identify the components of the air-acetylene torch outfit.
4. Identify the components of the air-propane torch outfit.
5. Discuss lighting, adjusting, and extinguishing the air-acetylene torch.
6. List four steps for proper care of the air-acetylene torch.
7. Identify the components of the oxyacetylene torch outfit.
8. Arrange in order the steps for setting up the oxyacetylene torch.
9. Arrange in order the steps for lighting, adjusting, and extinguishing the oxyacetylene torch.
10. List five steps for proper care of oxyacetylene welding equipment.
11. Identify electric welding equipment.
12. List three uses of the electric welder in the air-conditioning and refrigeration trade.
13. List steps used for proper care of the electric welder.
14. Demonstrate the ability to:
    a. Light and adjust the air-acetylene torch.
    b. Light and adjust the halide torch leak detector.
    c. Light and adjust the oxyacetylene torch.

SOLDERING AND WELDING EQUIPMENT
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss the procedures outlined in the job sheets.

  G. Demonstrate the proper use of soldering and welding equipment.

  H. Invite an outside resource person to talk to class about welding equipment.

  I. Demonstrate the explosiveness of welding gas.

  J. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

C. Transparency masters

1. TM 1--Air-Acetylene Torch Outfit
2. TM 2--Air-Acetylene Torch Outfit (Continued)
3. TM 3--Air-Propane Torch Outfit
4. TM 4--Air-Propane Torch Outfit (Continued)
5. TM 5--Oxyacetylene Torch Outfit
6. TM 6--Oxyacetylene Torch Outfit (Continued)
7. TM 7--Electric Welding Equipment
8. TM 8--Electric Welding Equipment (Continued)

D. Job sheets

1. Job Sheet #1--Light and Adjust the Air-Acetylene Torch
2. Job Sheet #2--Light and Adjust the Halide Torch Leak Detector
3. Job Sheet #3--Light and Adjust the Oxyacetylene Torch

E. Test

F. Answers to test

II. References:

A. *The Oxy-Acetylene Handbook.* New York, New York: Linde Division/Union Carbide Corp., 1968.

B. Sosnin, H. A. *Arc Welding Instructions for the Beginner.* Cleveland, Ohio: The James F. Lincoln Arc Welding Foundation, 1973.

C. *Welding Curriculum.* Stillwater, Oklahoma: State Department of Vocational and Technical Education, 1974.

SOLDERING AND WELDING EQUIPMENT
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Regulator--Device for reducing high cylinder pressure to a low working pressure

B. Flashback--Fire inside the torch

C. Flashback valve--One-way valve which prevents a flashback from going up the hoses and to the regulators

D. Air-acetylene torch--Torch which uses an acetylene cylinder only and gets the oxygen to support the flame from the surrounding air

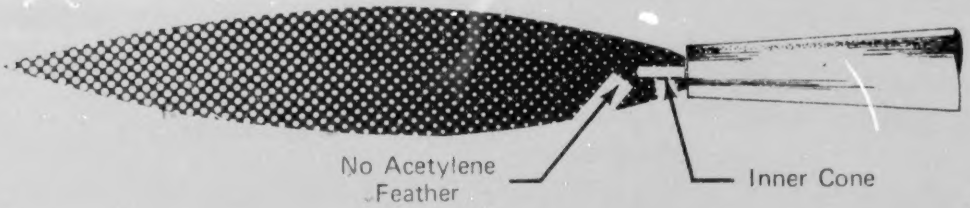
E. Arc--Flow of electric current from the tip of the electrode holder to the metal being welded

F. Electrodes--Metal rods which conduct a current from the electrode holder to the metal being welded

G. Inner cone--Inner white part of a neutral flame

H. Neutral flame--Burning of equal parts of oxygen and acetylene (Figure 1)

Figure 1



I. Soldering--Joining two metals by adhesion of a low melting temperature metal

(NOTE: Low melting temperature is usually considered 800°F or less.)

J. Silver brazing--Joining two metals by adhesion of a high temperature soldering alloy which contains some percentage of silver

(NOTE: Temperature in silver brazing is usually around 900° to 1400°F.)

INFORMATION SHEET

II. Safety rules for using soldering and welding equipment

A. Gas welding and soldering

1. Always wear suitable protective clothing
2. Always keep a safe, clean work area
3. Make sure there are no flammable materials near
4. Do not weld in the vicinity of explosive materials or near carbon tetrachloride
5. Always make sure you have enough ventilation to give three or four complete changes of air per hour
6. Use air exhaust at the weld whenever welding lead, cadmium, chromium, manganese, brass, bronze, zinc, or galvanized metals

   (NOTE: Some silver soldering alloys contain cadmium. Cadmium free alloys should be purchased whenever possible.)
7. Never weld or cut in a confined area without protection
8. Handle all pressure cylinders with care
9. Keep all welding equipment in good condition
10. Do not use oil or grease on any oxygen or acetylene connections
11. Never open tank valves until you are certain that regulator valves are closed
12. Never open the valves on the cylinders with a hammer
13. Never hammer on oxygen or acetylene regulators
14. Do not light a torch with a match or open flame; use striker provided
15. Before lighting torch, be positive that hose, tanks, or any inflammable material will not be exposed to heat, flame, or sparks
16. Beware of high acetylene pressure; never use acetylene gas when the pressure is greater than 15 lbs. p.s.i.

    (NOTE: Acetylene gas when compressed to more than 15 lbs. becomes a very high explosive.)

INFORMATION SHEET

17. Never screw the regulator screw in tight against the regulator as this spoils the diaphragm

    (NOTE: If hose pressure drops, check tank pressure at regulator; tank is probably empty.)

18. Do not hold welding or cutting tip too close to your work; this may cause a flashback in your torch

19. Never use a tip that gets hot

    (NOTE: A hot tip or handle is caused by the burning of oxygen and acetylene inside of the tip or handle. This is a dangerous situation which should be repaired immediately.)

20. Never use a torch that leaks

21. Never leave your torch burning unattended

22. Never leave torch valve open

23. Do not use the torch for a hammer, crowbar, wedge, or for any purpose other than welding; do not use a cylinder, even when empty, as a roller

24. Do not store cylinders in a room where the temperature is more than 80°

25. Do not adjust, alter, change, build, or do any experimental work on cylinders, regulators, torches, or any other gas equipment

26. Never attempt to weld a closed or jacketed tank, vessel, or container without a vent for air

    (NOTE: Even with a vent, great care should be used not to get gas in tank. If for any reason you should get gas in the tank, be sure to aerate the tank.)

27. Use a regulator on air-acetylene torches

28. Stand to one side of regulator while slowly opening the cylinder valve

29. Purge oxygen and acetylene passages before lighting torch

30. Secure all cylinders to prevent them from being knocked over

31. Purge cylinder valve before attaching regulators

INFORMATION SHEET

32. Release adjusting screws on regulator before opening cylinder valve
33. Do not use a torch on a pressurized system
34. Light acetylene before opening oxygen valve on torch
35. Install flashback valves on all oxyacetylene welding equipment
36. Do not use oxygen as a substitute for compressed air
37. Keep heat, flames, and sparks away from combustibles

B. Electric welding

1. If it is necessary to couple lengths of cable together, make sure joints are insulated and all electrical connections are tight; use no cables with frayed, cracked, or bare spots
2. When electrode holder is not in use, hang it on welding machine or special holder; never let it touch a gas cylinder
3. Always have welding machine properly grounded
4. Make sure pedal controls are guarded to prevent accidental starts
5. If need arises to weld in damp or wet conditions, wear rubber boots and/or stand on dry cardboard or wood
6. Stand only on solid items, floor or ground
7. When welding in high places without railings, use safety belt or lifeline
8. Always wear proper eye protection, especially when grinding or cutting
9. Keep your booth curtains closed to protect the eyes of others
10. Never weld or cut directly on a concrete floor
11. Do not look at the arc with the naked eye
12. Wear a head or face shield that is in good condition
13. Always wear suitable protective clothing

    Examples: Long sleeved shirt, leather gloves, turned down cuffs, high top shoes or boots, buttoned down collar

INFORMATION SHEET

14. Do not strike an arc or weld until you are sure those in the vicinity have protective equipment or will look in the other direction

    (NOTE: Shout "COVER" before striking the arc.)

15. Do not pick up hot metal

16. Do not weld in confined places without proper ventilation

17. Open main switch or disconnect plug when checking a welder

18. Do not leave electrode holder on welding table or in direct contact with grounded metal

19. Do not use worn or frayed cables

III. Components of the air-acetylene torch outfit (Transparencies 1 and 2)

A. Torch handle

B. Regulator

C. Hose

D. Tips

   1. No. 1--Very fine pointed flame

   2. No. 2--Fine

   3. No. 3--Medium

   4. No. 4--Medium large

   5. No. 5--Large

   6. No. 6--Extra large

E. High temperature wraparound flame tip

F. Halide torch leak detectors

G. Soldering copper

H. Acetylene tanks

   1. "B" tank

      (NOTE: This has a capacity of 40 cubic feet.)

INFORMATION SHEET

2. "MC" tank

(NOTE: This has a capacity of 10 cubic feet.)

I. Striker

J. Cylinder wrench

IV. Components of the air-propane torch outfit (Transparencies 3 and 4)

A. Torch handle

B. Regulator

C. High temperature wraparound flame tip

D. Standard tips

1. Small

2. Medium

3. Large

E. Halide torch leak detector

F. Soldering copper

G. Liquified petroleum cylinders

1. 2 1/2 lb. capacity

2. 20 lb. capacity

H. Hose--B size with left-hand nuts

I. Striker

V. Lighting, adjusting, and extinguishing the air-acetylene torch

A. Open tank valve 1/2 of a turn

(NOTE: Use a tank key or a refrigeration ratchet handle to open the tank valve.)

B. Open valve on handle

C. Ignite gas with a striker

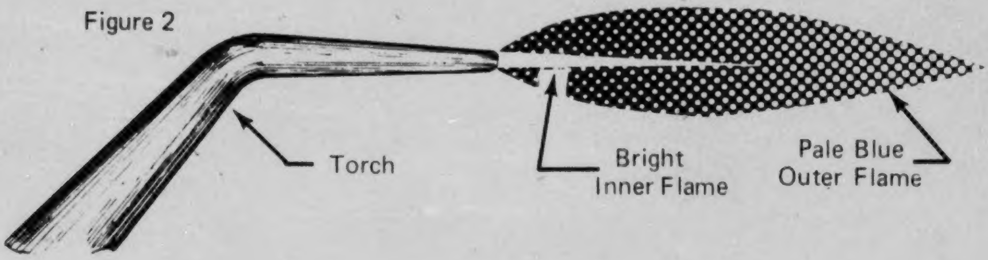
INFORMATION SHEET

D. Turn handle valve to adjust flame

E. Adjust flame so that the inner blue cone is about 1 1/2" long (Figure 2)

(NOTE: The hottest part of the flame is 1/8" from the inner blue cone.)

Figure 2



F. Extinguish the flame

1. Close tank valve
2. Let flame burn itself out
3. Close valve on handle

VI. Care of the air-acetylene torch

A. Secure tank from falling over

B. Don't overtighten regulator adjustment

C. Keep tips clean

D. Check for acetylene leaks before using

VII. Components of the oxyacetylene torch outfit (Transparencies 5 and 6)

A. Oxygen regulator

B. Acetylene regulator

C. Torch handle

D. Cutting attachment

E. Welding tip

F. Cutting tip

INFORMATION SHEET

G. Twin hose

H. Safety goggles

I. Striker

J. Cart

K. Oxygen cylinder

L. Acetylene cylinder

VIII. Steps for setting up the oxyacetylene torch

A. Fasten cylinders in a vertical position

B. Remove caps from cylinders

C. Crack valves of each cylinder, then close valves

D. Connect oxygen regulator to oxygen cylinder

(CAUTION: Do not lubricate.)

1. Turn pressure adjusting screw on regulator counterclockwise until tension on spring is released

2. Slowly open cylinder and tighten in open position

E. Connect acetylene regulator to acetylene cylinder

1. Turn pressure adjusting screw on regulator counterclockwise until tension on spring is released

2. Open cylinder valve 1/2 to 3/4 of a turn

(NOTE: Never open more than 1 1/2 turns.)

F. Connect acetylene hose (red) to acetylene regulator and purge hose

(NOTE: All acetylene fittings have a grooved nut to indicate left-hand threads.)

G. Connect oxygen hose (green) to oxygen regulator and purge hose

(NOTE: All oxygen fittings have right-hand threads.)

H. Connect torch body to oxygen and acetylene hose and close both valves on torch body

INFORMATION SHEET

I. Attach welding tip to torch body

(NOTE: Size of tip is determined by thickness of metal to be welded. Use manufacturer's recommendations for tip size and working pressures.)

J. Turn pressure adjusting screw on oxygen regulator clockwise until working pressure is reached

K. Turn pressure adjusting screw on acetylene regulator clockwise until working pressure is reached

L. Test all connections for leaks with soap suds and water

(NOTE: Apply soap suds with a clean paint brush.)

IX. Steps for lighting, adjusting, and extinguishing the oxyacetylene torch

A. Lighting

1. Check all cylinder, regulator, and torch valves to make sure they are turned off
2. Open acetylene cylinder valve 1/2 to 3/4 of a turn

   (CAUTION: Never open more than 1 1/2 turns.)
3. To purge line, open acetylene valve on torch one turn
4. Turn acetylene regulator pressure adjusting screw clockwise until desired working pressure is reached
5. Close acetylene valve on torch
6. Open oxygen cylinder valve all the way and tighten in open position
7. Open oxygen torch valve one turn
8. Turn oxygen regulator pressure adjusting screw clockwise until desired pressure is reached
9. Close oxygen valve on torch
10. Open acetylene valve on torch 1/4 turn
11. Light the torch with flint lighter

INFORMATION SHEET

B. Adjusting

1. Adjust until smoke on flame clears
2. Open oxygen torch valve
3. Adjust to a neutral flame with a tiny trace of feather on the inner cone

   (NOTE: The working pressure is determined by the size of the tip.)

C. Extinguishing

1. Close acetylene torch valve
2. Close oxygen torch valve
3. Close acetylene cylinder valve
4. Close oxygen cylinder valve
5. Open acetylene torch valve

   (NOTE: When gauges reach O, release acetylene regulator pressure adjusting screw and close torch valve.)

6. Open oxygen valve on torch

   (NOTE: When gauges reach O, release oxygen regulator pressure adjusting screw and close torch valve.)

7. Place torch and hoses on hanger or brackets

X. Care of oxyacetylene welding equipment

A. Use no oil around the equipment

B. Do not leave pressure on regulators

C. Keep tips clean

D. Check for loose or leaky fittings

E. Keep hose off of the floor as much as possible

INFORMATION SHEET

XI. Equipment for electric welding (Transparencies 7 and 8)

A. Electric welder

B. Electrode holder

C. Ground clamp

D. Shield

E. Gloves

F. Chipping hammer

G. Safety goggles

H. Wire brush

I. Electrode

XII. Uses of the electric welder in the air-conditioning and refrigeration trade

A. Constructing angle iron equipment racks

B. Fabricating compressor mounting plates

C. Repairing broken braces and supports

XIII. Care of the electric welder

A. Cables should be correct size

B. Cables should be well insulated

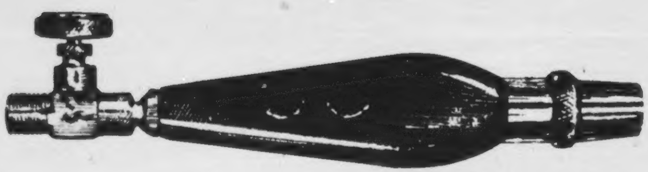
C. Check cables for defective insulation periodically

D. Keep all cable connections tight

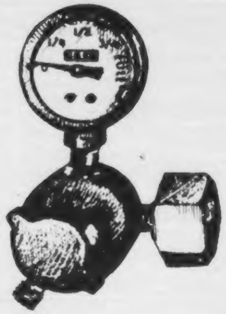
E. Check the insulation on the electrode holder

F. Holder should grip the electrode tightly

Air-Acetylene Torch Outfit

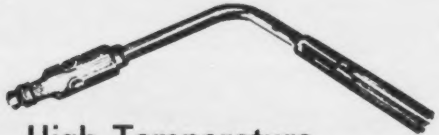


Torch Handle

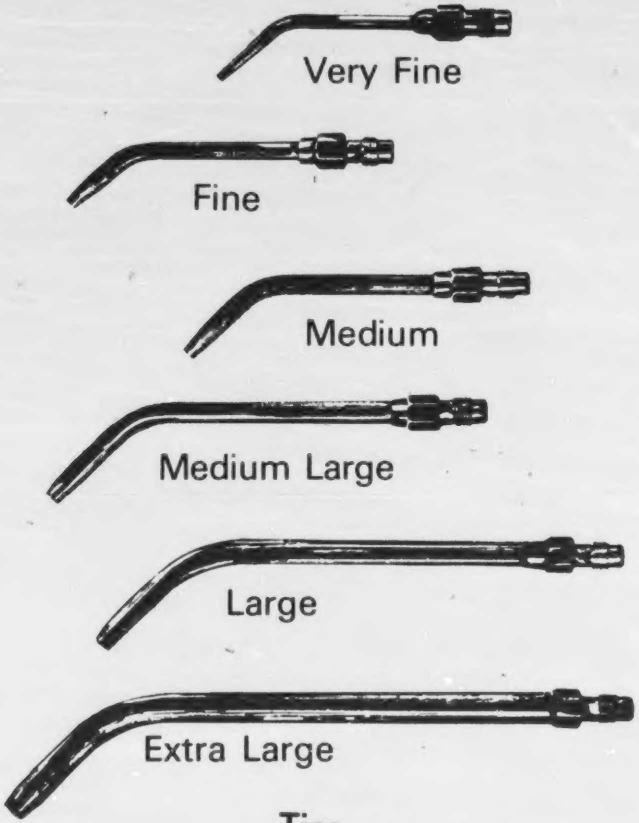


Regulator

Hose



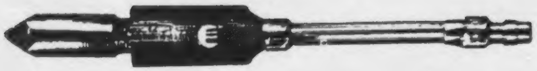
High Temperature
Wraparound Flame Tip


Very Fine
Fine
Medium
Medium Large
Large
Extra Large

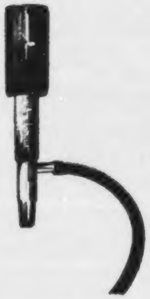
Tips

Air-Acetylene Torch Outfit

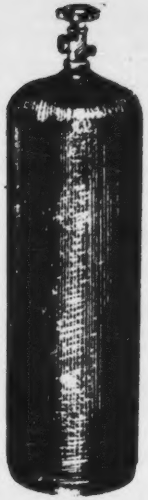
(Continued)



Soldering Copper

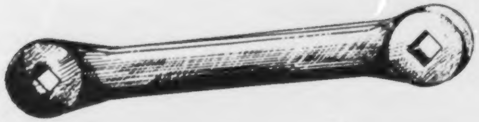


Halide Torch Leak Detector

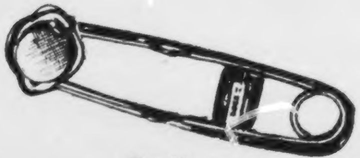


"B" Acetylene Tank

"MC" Acetylene Tank

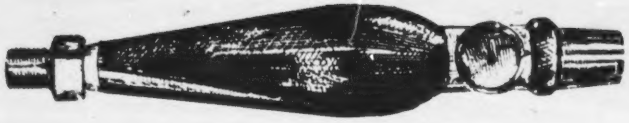


Cylinder Wrench

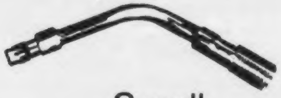


Striker

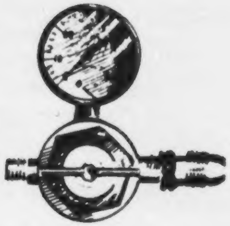
Air-Propane Torch Outfit



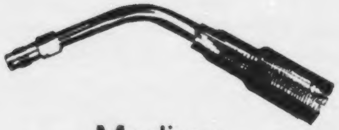
Torch Handle



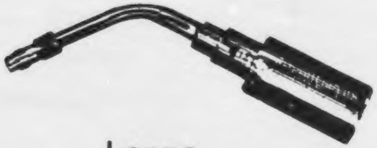
Small



Regulator

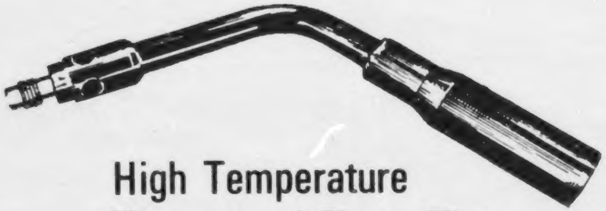


Medium



Large

Standard Tips



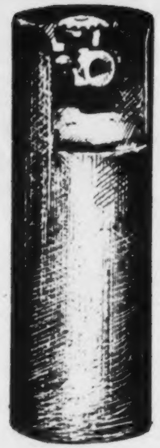
High Temperature
Wraparound Flame Tip

TM - 3

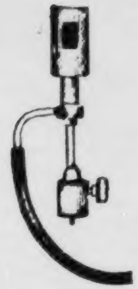
ACR I - 21-E

Air-Propane Torch Outfit

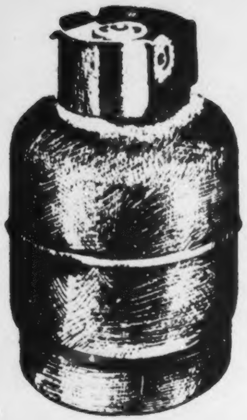
(Continued)



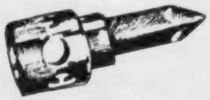
Liquified Petroleum Cylinder
2 1/2 lb. Capacity



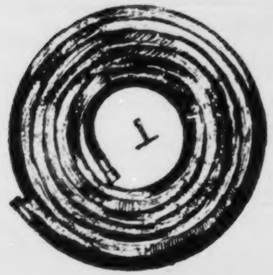
Halide Torch Leak Detector



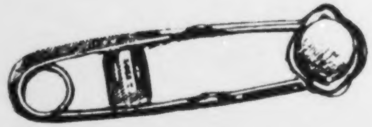
Liquified Petroleum Cylinder
20 lb. Capacity



Soldering Copper



Hose



Striker

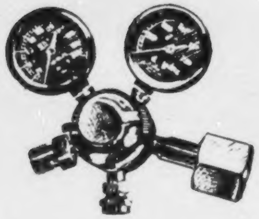
TM - 4

ACR I - 23-E

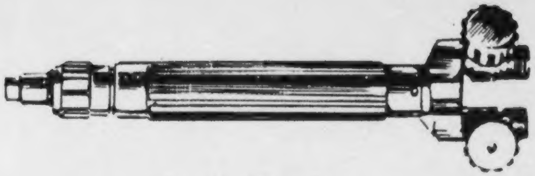
426

427

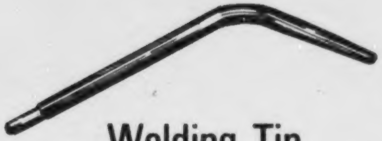
Oxyacetylene Torch Outfit



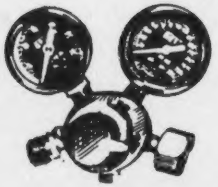
Oxygen Regulator



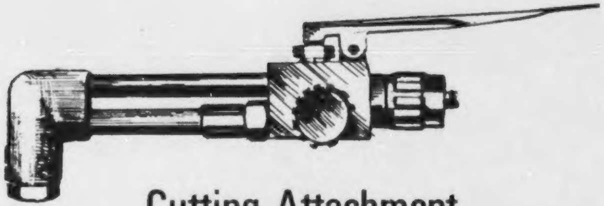
Torch Handle



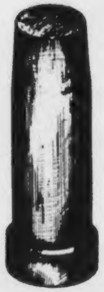
Welding Tip



Acetylene Regulator



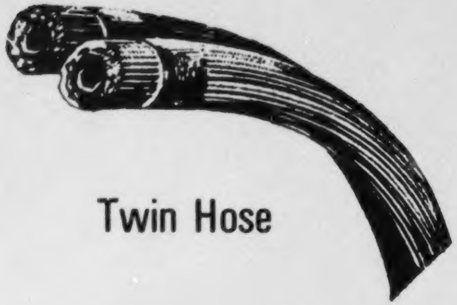
Cutting Attachment



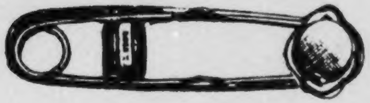
Cutting Tip

Oxyacetylene Torch Outfit

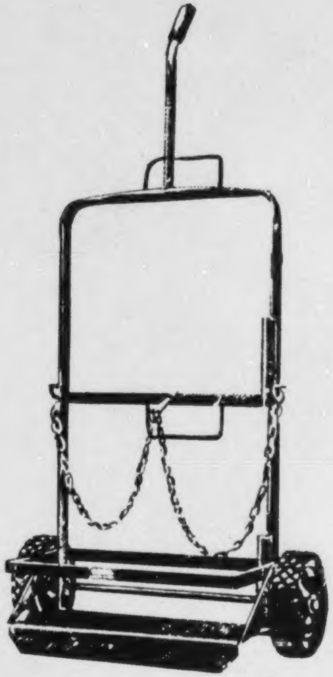
(Continued)



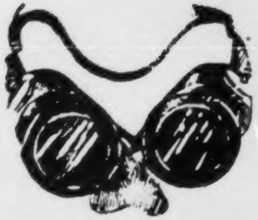
Twin Hose



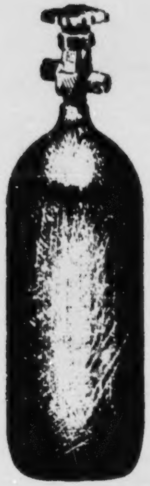
Striker



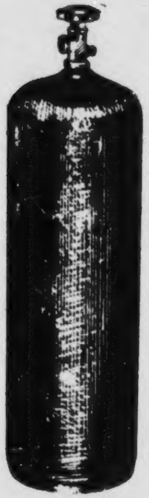
Cart



Safety Goggles

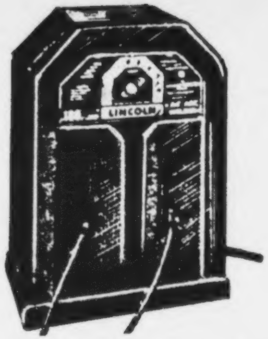


Oxygen Cylinder

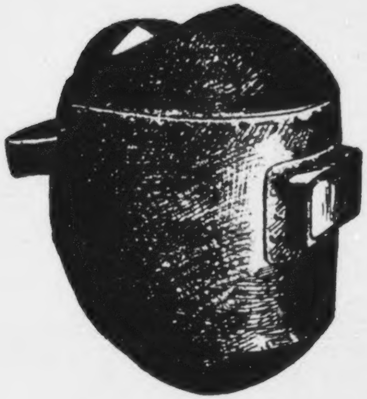


Acetylene Cylinder

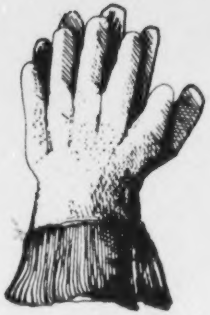
Electric Welding Equipment



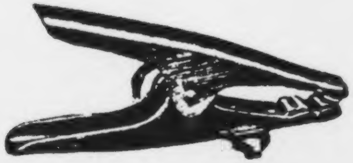
Electric Welder



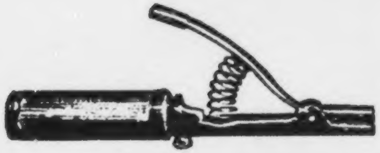
Shield



Gloves



Ground Clamp



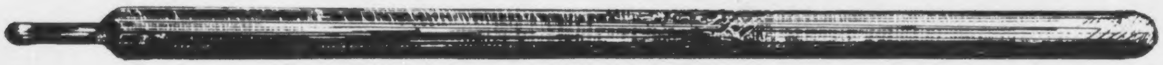
Electrode Holder

TM - 7

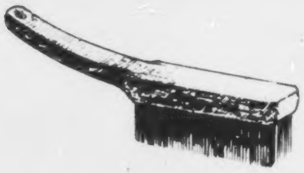
ACR I - 29-E

Electric Welding Equipment

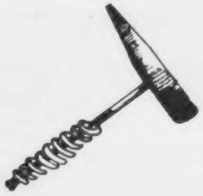
(Continued)



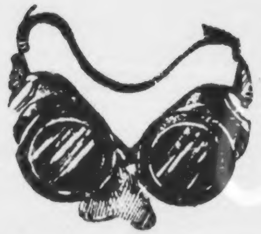
Electrode



Wire Brush



Chipping Hammer



Safety Goggles

SOLDERING AND WELDING EQUIPMENT
UNIT I

JOB SHEET #1--LIGHT AND ADJUST THE AIR-ACETYLENE TORCH

I. Tools and materials

   A. Air-acetylene torch outfit

   B. Acetylene tank valve wrench

   C. Striker

   D. Colored safety glasses

II. Procedure

   A. Put on colored safety glasses

   B. Open tank valve 1/2 of a turn

   C. Check system for leaks with soap bubbles

   (CAUTION: Never check for a gas leak with a flame.)

   D. Open torch handle valve 1/4 of a turn

   E. Strike striker immediately

   F. Upon ignition of flame, open torch valve another 1/2 of a turn

   (CAUTION: If flame does not ignite immediately, shut off valve on handle. Delayed ignition could cause an explosion.)

   G. Adjust flame so that inner blue cone is about 1 1/2" long

   (NOTE: If there is an air gap between the inner blue cone and the torch tip, the regulator adjusting screw may need to be turned counterclockwise in order to decrease the pressure.)

   H. Extinguish by closing tank valve first

   I. Let flame burn itself out

   J. Close torch handle valve

   K. Roll up hose

   L. Put away equipment

SOLDERING AND WELDING EQUIPMENT
UNIT I

JOB SHEET #2--LIGHT AND ADJUST THE HALIDE TORCH LEAK DETECTOR

I. Tools and materials

  A. Air-acetylene torch outfit

  B. Halide torch leak detector

  C. Acetylene tank valve wrench

  D. Striker

  E. Safety glasses

II. Procedure

  A. Put on safety glasses

  B. Remove tip from torch handle by turning tip counterclockwise

  C. Install the halide torch leak detector in the torch handle

  D. Open tank valve 1/2 of a turn

  E. Check system for leaks with soap bubbles

  (CAUTION: Never check for a gas leak with a flame.)

  F. Open torch handle valve 1/4 of a turn

  G. Hold striker over end of leak detector while striking

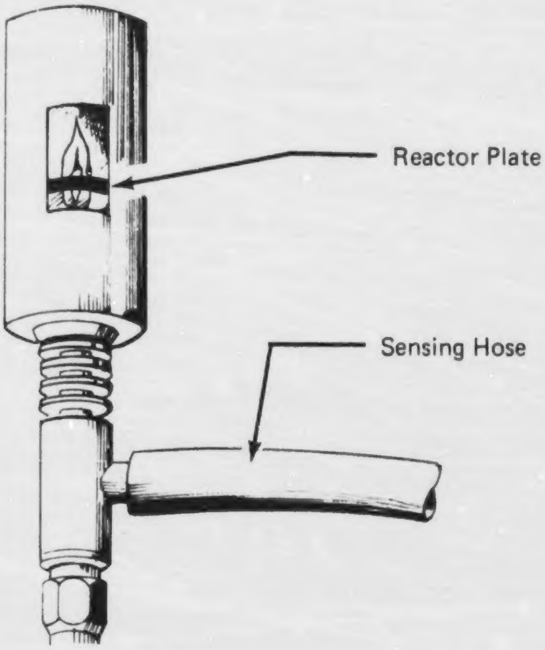
  H. Place thumb over end of sniffer hose while lighting detector flame

  I. Remove thumb as soon as flame is lit

JOB SHEET #2

J. Adjust flame so that inner blue cone just barely touches the reactor plate (Figure 1)

Figure 1



K. Extinguish by closing tank valve first

L. Let flame burn itself out

M. Close torch handle valve

N. Remove leak detector from torch handle

O. Replace tip in torch handle

P. Roll up hose

Q. Put away equipment

SOLDERING AND WELDING EQUIPMENT
UNIT I

JOB SHEET #3--LIGHT AND ADJUST THE OXYACETYLENE TORCH

I. Tools and materials

- A. Oxyacetylene welding outfit
- B. Welding goggles
- C. Striker

II. Procedure

- A. Check all cylinder, regulator, and torch valves to make sure they are turned off
- B. Open acetylene cylinder valve 1/2 to 3/4 of a turn

  (CAUTION: Never open more than 1 1/2 turns.)
- C. To purge line, open acetylene valve on torch one turn
- D. Turn acetylene regulator pressure adjusting screw clockwise until desired working pressure is reached
- E. Close acetylene valve on torch
- F. Open oxygen cylinder valve all the way and tighten in open position
- G. Open oxygen torch valve one turn
- H. Turn oxygen regulator pressure adjusting screw clockwise until desired pressure is reached
- I. Close oxygen valve on torch
- J. Open acetylene valve on torch 1/4 turn
- K. Light the torch with striker and adjust until smoke on flame clears
- L. Open oxygen torch valve and adjust to a neutral flame with a tiny trace of feather on the inner cone
- M. Turn off the torch and oxyacetylene welding outfit using the following procedure:
  1. Close acetylene torch valve
  2. Close oxygen torch valve

JOB SHEET #3

3. Close acetylene cylinder valve

4. Close oxygen cylinder valve

5. Open acetylene torch valve

   (NOTE: When gauges reach O, release acetylene regulator pressure adjusting screw and close torch valve.)

6. Open oxygen valve on torch

   (NOTE: When gauges reach O, release oxygen regulator pressure adjusting screw and close torch valve.)

7. Place torch and hoses on hanger or brackets

SOLDERING AND WELDING EQUIPMENT
UNIT I

TEST

1. Match the terms on the right to the correct definitions.

______a. Joining two metals by adhesion of a high temperature soldering alloy which contains some percentage of silver

______b. Fire inside the torch

______c. Device for reducing high cylinder pressure to a low working pressure

______d. Joining two metals by adhesion of a low melting temperature metal

______e. Flow of electric current from the tip of the electrode holder to the metal being welded

______f. Inner white part of a neutral flame

______g. Burning of equal parts of oxygen and acetylene

______h. Metal rods which conduct a current from the electrode holder to the metal being welded

______i. Torch which uses an acetylene cylinder only and gets the oxygen to support the flame from the surrounding air

______j. One-way valve which prevents a flashback from going up the hoses and to the regulators

1. Inner cone
2. Air-acetylene torch
3. Regulator
4. Arc
5. Neutral flame
6. Silver brazing
7. Soldering
8. Electrodes
9. Flashback valve
10. Flashback

2. Select safety rules for using soldering and welding equipment by placing an "X" in the appropriate blank.

______a. Do not weld in the vicinity of explosive materials or near carbon tetrachloride

______b. Always make sure you have enough ventilation to give three or four complete changes of air per day

______c. Use air exhaust at the weld whenever welding lead, cadmium, chromium, manganese, brass, bronze, zinc, or galvanized metals

______d. Never use a torch that leaks

______e. Never leave your torch burning unattended

______f. Never leave torch valve open

______g. Do not use the torch for a hammer, crowbar, wedge, or for any purpose other than welding; do not use a cylinder, even when empty, as a roller

______h. Do not use oil or grease on any oxygen or acetylene connections

______i. Never open tank valves until you are certain that regulator valves are open

______j. Open the valves on the cylinders with a hammer

______k. Always wear suitable protective clothing

______l. Always keep a safe, clean work area

______m. Make sure there are no flammable materials near

______n. Before lighting torch, be positive that hose, tanks, or any inflammable material will not be exposed to heat, flame, or sparks

______o. Beware of high acetylene pressure; never use acetylene gas when the pressure is greater than 15 lbs. p.s.i.

______p. Do not store cylinders in a room where the temperature is less than 80°

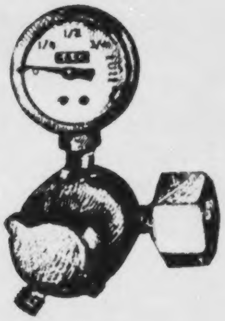
______q. Do not adjust, alter, change, build, or do any experimental work on cylinders, regulators, torches, or any other gas equipment

______r. Always weld a closed or jacketed tank, vessel, or container without a vent for air

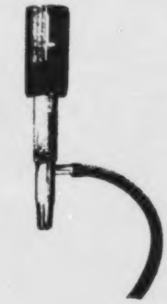
______s. Never hammer on oxygen or acetylene regulators

______t. Do not light a torch with a match or open flame; use striker provided

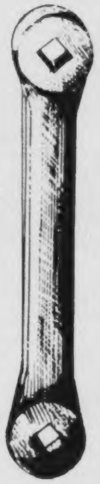
3. Identify the components of the air-acetylene torch outfit.



a. ____________________

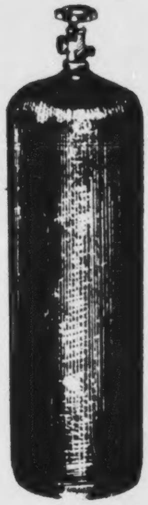


b. ____________________

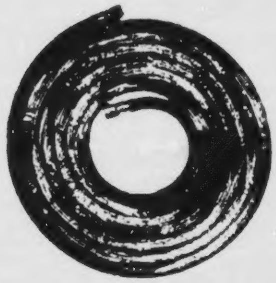


c. ____________________

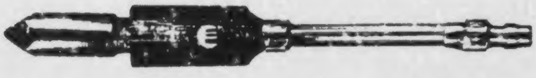
d. ____________________



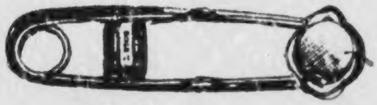
e. ____________________



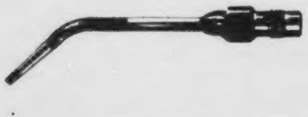
f. ____________________



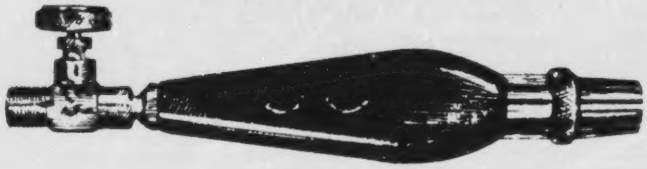
g. ____________________



h. ____________________

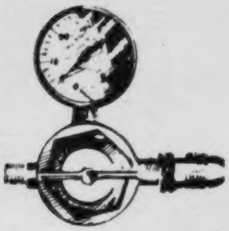


i. ____________________

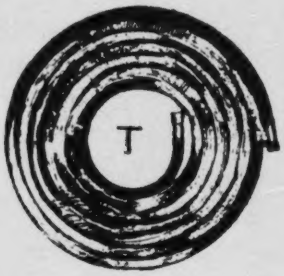


j. ____________________

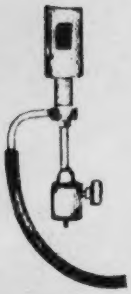
4. Identify the components of the air-propane torch outfit.



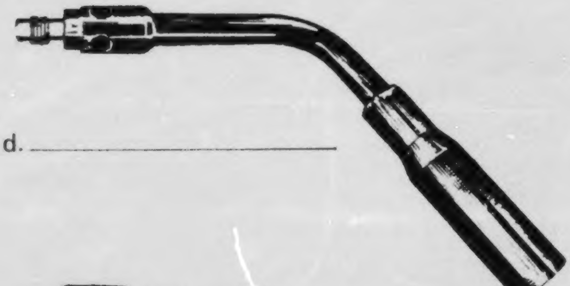
a. ______________________



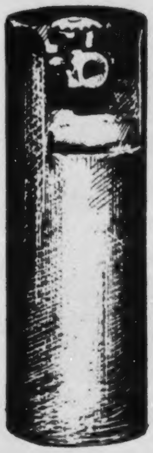
b. ______________________

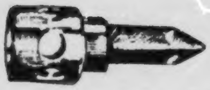


c. ______________________



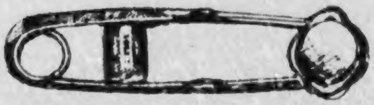
d. ______________________



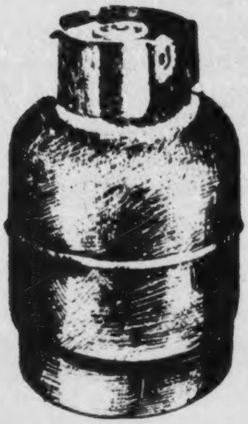


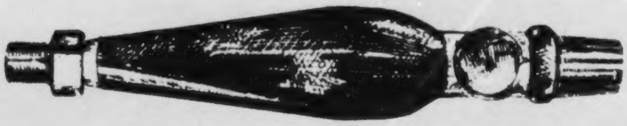
g. ______________________

e. ______________________



f. ______________________





i. ______________________

h. ______________________

5. Discuss lighting, adjusting, and extinguishing the air-acetylene torch.

6. List four steps for proper care of the air-acetylene torch.

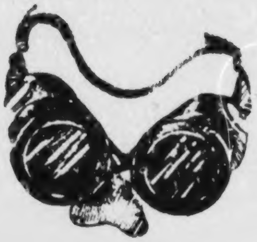
   a.

   b.

   c.

   d.

7. Identify the components of the oxyacetylene torch outfit.



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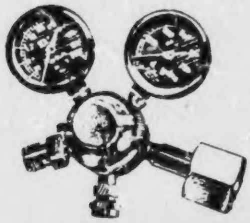

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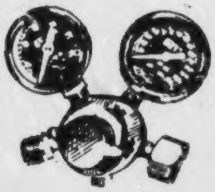

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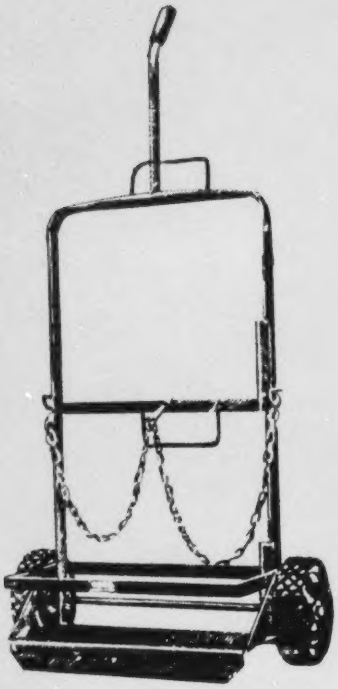

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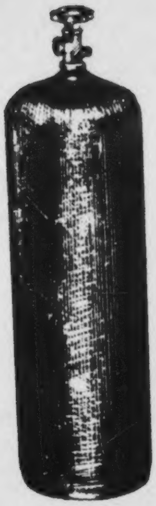

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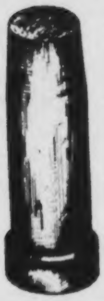

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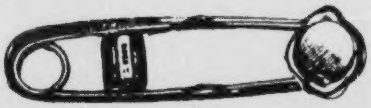

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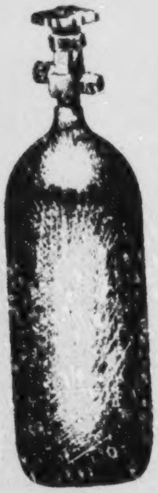
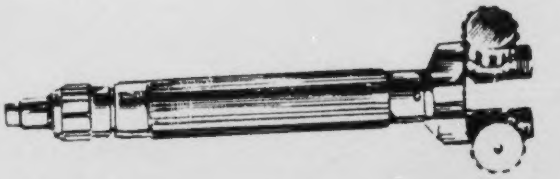


h. ____________



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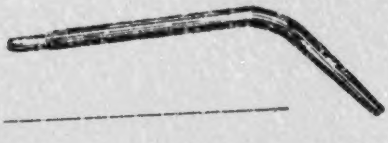

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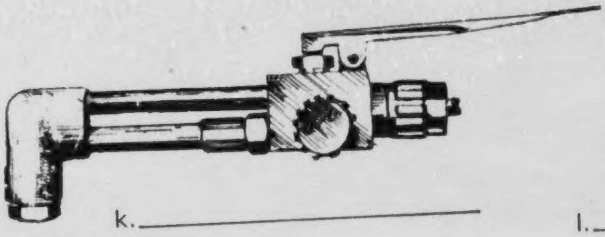

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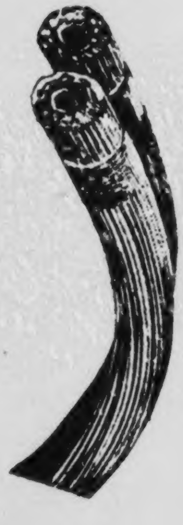


l. ____________________

8. Arrange in order the following steps by placing the correct sequence number in the appropriate blank.

   ______a. Connect acetylene hose (red) to acetylene regulator and purge hose

   ______b. Remove caps from cylinders

   ______c. Turn pressure adjusting screw on oxygen regulator clockwise until working pressure is reached

   ______d. Test all connections for leaks with soap suds and water

   ______e. Fasten cylinders in a vertical position

   ______f. Connect acetylene regulator to acetylene cylinder

      1) Turn pressure adjusting screw on regulator counterclockwise until tension on spring is released

      2) Open cylinder valve 1/2 to 3/4 of a turn

   ______g. Attach welding tip to torch body

   ______h. Connect oxygen regulator to oxygen cylinder

      1) Turn pressure adjusting screw on regulator counterclockwise until tension on spring is released

      2) Slowly open cylinder and tighten in open position

   ______i. Crack valves of each cylinder, then close valves

   ______j. Connect oxygen hose (green) to oxygen regulator and purge hose

   ______k. Turn pressure adjusting screw on acetylene regulator clockwise until working pressure is reached

   ______l. Connect torch body to oxygen and acetylene hose and close both valves on torch body

9. Arrange in order the following steps by placing the correct sequence letter in the appropriate blank.

   a. Lighting

      ____ 1) To purge line, open acetylene valve on torch one turn

      ____ 2) Turn oxygen regulator pressure adjusting screw clockwise until desired pressure is reached

      ____ 3) Check all cylinder, regulator, and torch valves to make sure they are turned off

____ 4) Turn acetylene regulator pressure adjusting screw clockwise until desired working pressure is reached

____ 5) Open oxygen torch valve one turn

____ 6) Open acetylene cylinder valve 1/2 to 3/4 of a turn

____ 7) Close oxygen valve on torch

____ 8) Close acetylene valve on torch

____ 9) Light the torch with flint lighter

____10) Open oxygen cylinder valve all the way and tighten in open position

____11) Open acetylene valve on torch 1/4 turn

b. Adjusting

____ 1) Adjust to a neutral flame with a tiny trace of feather in the cone

____ 2) Adjust until smoke on flame clears

____ 3) Open oxygen torch valve

c. Extinguishing

____ 1) Close oxygen cylinder valve

____ 2) Place torch and hoses on hanger or brackets

____ 3) Close acetylene torch valve

____ 4) Open acetylene torch valve

____ 5) Open oxygen valve on torch

____ 6) Close oxygen torch valve

____ 7) Close acetylene cylinder valve

10. List five steps for proper care of oxyacetylene welding equipment.

a.

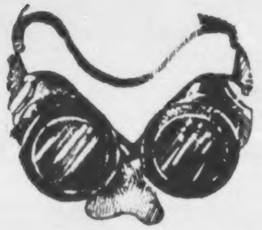
b.

c.

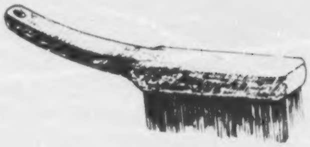
d.

e.

11. Identify the electric welding equipment.



a. ____________________



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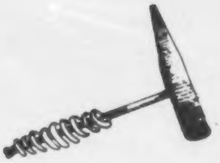
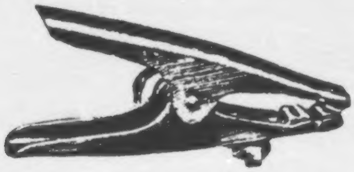
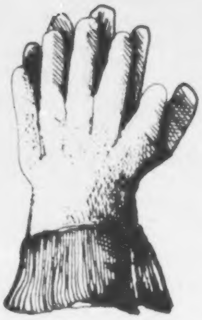


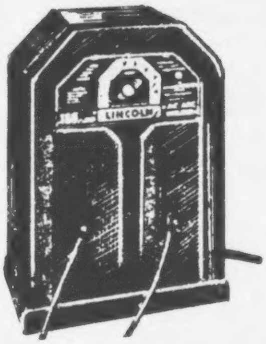
c. ____________________



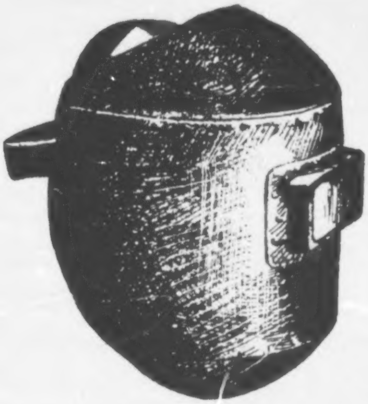
d. ____________________



e. ____________________

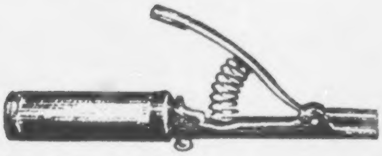


g. ____________________



f. ____________________

i. ____________________



h. ____________________

12. List three uses of the electric welder in the air-conditioning and refrigeration trade.

    a.

    b.

    c.

13. List four steps used for proper care of the electric welder.

    a.

    b.

    c.

    d.

14. Demonstrate the ability to:

    a. Light and adjust the air-acetylene torch.

    b. Light and adjust the halide torch leak detector.

    c. Light and adjust the oxyacetylene torch.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SOLDERING AND WELDING EQUIPMENT
UNIT I

ANSWERS TO TEST

1. a. 6
   b. 10
   c. 3
   d. 7
   e. 4
   f. 1
   g. 5
   h. 8
   i. 2
   j. 9

2. a, c, d, e, f, g, h, k, l, m, n, o, q, s, t

3. a. Regulator
   b. Halide torch leak detector
   c. Cylinder wrench
   d. "MC" acetylene tank
   e. "B" acetylene tank
   f. Hose
   g. Soldering copper
   h. Striker
   i. Tip
   j. Torch handle

4. a. Regulator
   b. Hose
   c. Halide torch leak detector
   d. High temperature wraparound flame tip
   e. Liquified petroleum cylinder 2 1/2 lb. capacity
   f. Striker
   g. Soldering copper

- h. Liquified petroleum cylinder 20 lb. capacity
- i. Torch handle

5. Discussion should include:
    - a. Open tank valve 1/2 of a turn
    - b. Open valve on handle
    - c. Ignite gas with a striker
    - d. Turn handle valve to adjust flame
    - e. Adjust flame so that the inner blue cone is about 1 1/2" long
    - f. Extinguish the flame
        - 1) Close tank valve
        - 2) Let flame burn itself out
        - 3) Close valve on handle

6. a. Secure tank from falling over
    - b. Don't overtighten regulator adjustment
    - c. Keep tips clean
    - d. Check for acetylene leaks before using

7. a. Safety goggles
    - b. Oxygen regulator
    - c. Acetylene regulator
    - d. Cart
    - e. Acetylene cylinder
    - f. Cutting tip
    - g. Striker
    - h. Oxygen cylinder
    - i. Torch handle
    - j. Welding tip
    - k. Cutting attachment
    - l. Twin hose

8. a. 6
   b. 2
   c. 10
   d. 12
   e. 1
   f. 5
   g. 9
   h. 4
   i. 3
   j. 7
   k. 11
   l. 8
9. a. 1) c
      2) h
      3) a
      4) d
      5) g
      6) b
      7) i
      8) e
      9) k
      10) f
      11) j
   b. 1) c
      2) a
      3) b
   c. 1) d
      2) g
      3) a
      4) e
      5) f
      6) b
      7) c
10. a. Use no oil around the equipment
    b. Do not leave pressure on regulators
    c. Keep tips clean
    d. Check for loose or leaky fittings
    e. Keep hose off of the floor as much as possible
11. a. Safety goggles
    b. Wire brush
    c. Chipping hammer
    d. Ground clamp

   - e. Gloves
   - f. Shield
   - g. Electric welder
   - h. Electrode holder
   - i. Electrode

12. a. Constructing angle iron equipment racks
    - b. Fabricating compressor mounting plates
    - c. Repairing broken braces and supports

13. Any four of the following:
    - a. Cables should be correct size
    - b. Cables should be well insulated
    - c. Check cables for defective insulation periodically
    - d. Keep all cable connections tight
    - e. Check the insulation on the electrode holder
    - f. Holder should grip the electrode tightly

14. Performance skills evaluated to the satisfaction of the instructor

SOFT SOLDERING
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with soft soldering to the correct definitions and discuss the types of soft solder and fluxes. The student should also be able to list the steps for making a solder joint and the conditions for proper capillary action of solders. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with soft soldering to the correct definitions.
2. Discuss the descriptions and uses of types of soft solder.
3. List the thirteen steps in making a solder joint.
4. Describe the types of flux used in soft soldering.
5. List the five conditions for creating capillary action of solders.
6. Demonstrate the ability to:
    a. Clean, flux, and solder a swage joint.
    b. Solder an inverted swage joint.
    c. Solder a horizontal swage joint.
    d. Soft solder with the oxyacetylene torch.

SOFT SOLDERING
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:
   - A. Provide student with objective sheet.
   - B. Provide student with information and job sheets.
   - C. Discuss unit and specific objectives.
   - D. Discuss information sheet.
   - E. Demonstrate and discuss the procedures outlined in the job sheets.
   - F. Give test.

II. Student:
   - A. Read objective sheet.
   - B. Study information sheet.
   - C. Complete job sheets.
   - D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:
   - A. Objective sheet
   - B. Information sheet
   - C. Job sheets
     1. Job Sheet #1--Clean, Flux, and Solder a Swage Joint
     2. Job Sheet #2--Solder an Inverted Swage Joint
     3. Job Sheet #3--Solder a Horizontal Swage Joint
     4. Job Sheet #4--Soft Solder with the Oxyacetylene Torch
   - D. Test
   - E. Answers to test

II. References:

A. *The Oxy-Acetylene Handbook.* New York, New York: Linde Division/Union Carbide Corp., 1968.

B. "Soldering and Brazing: The Mark of the Craftsman." Refrigeration Service and Contracting. March, 1975, p. 14.

SOFT SOLDERING
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Antimony--Alloy which is added to soft solder for added strength

B. Capillary action--The manner in which the molten solder is drawn into the joint through the proper application of heat

C. Soft solder--Solder with a melting temperature of 800°F or less, that is used as a filler metal

D. Flux--Mildly corrosive substance that is applied to a joint prior to soldering to prevent oxidation

E. Filler metal--Metal which is melted and is used to join two similar or dissimilar metals together

F. Oxidize--To combine with oxygen

(NOTE: This will create the accumulation of a film on the tubing that prevents the flow of solder.)

G. Eutectic solder--Solder having a low melting point

H. Topped--The process of melting a solder on top of the one that was used to make the joint to insure a leak proof joint

II. Descriptions and uses of types of soft solder

A. 50-50 solder

1. All purpose solder for plumbing

2. Easy to use

3. Composition

a. 50% tin

b. 50% lead

B. 95-5 solder

1. Usually used only when specified

INFORMATION SHEET

   2. Hard to use

      (NOTE: When used, it should be topped with 50-50 solder.)

   3. Composition

      a. 95% tin

      b. 5% antimony

C. 40-60 solder

   1. Will not flow as well as 50-50

   2. Not generally used

   3. Composition

      a. 40% tin

      b. 60% lead

D. 63-37 solder

   1. A eutectic solder

      a. Very strong

      b. Low melting temperature

   2. Used where low melting temperatures are necessary

   3. Composition

      a. 63% tin

      b. 37% lead

E. 97-3 solder

   1. A silver bearing soft solder

      a. Good strength

      b. Excellent flowing qualities

   2. Used for food processing equipment

   3. Composition

      a. 97% tin

      b. 3% silver

INFORMATION SHEET

III. Steps for making a solder joint
   - A. Measure length of tube
   - B. Cut tube square
   - C. Ream cut end
   - D. Clean tube end
   - E. Clean fitting socket
   - F. Apply flux to tube end
   - G. Assemble
   - H. Remove excess flux
   - I. Vent with dry nitrogen
   - J. Apply heat
   - K. Apply solder
   - L. Allow joint to cool
   - M. Clean the joint

IV. Types of flux for soft solder
   - A. Mildly corrosive paste flux
      - 1. Composed of
         - a. Zinc
         - b. Ammonium
      - 2. Aids in easy flowing of solder

   (NOTE: This flux is recommended for use with 50-50 and 95-5 solder.)

   - B. Liquid self-cleaning fluxes
      - 1. Nonuniform cleaning
      - 2. Could create contamination

   (NOTE: This type of flux is not recommended for refrigeration work.)

INFORMATION SHEET

V. Conditions for creating capillary action of solders

   A. Proper joint fit

   B. Correct heat temperature

   C. Even heating

   D. Properly cleaned joint

   E. Correct flux

SOFT SOLDERING
UNIT II

JOB SHEET #1--CLEAN, FLUX, AND SOLDER A SWAGE JOINT

I. Tools and materials

A. Tubing cutter

B. Reamer

C. Flaring block

D. Swage punch

E. Ball peen hammer

F. Soft copper tubing

G. Fine sand cloth or special pads

(NOTE: Do not use emery cloth when working with refrigerant lines.)

H. Low corrosive paste flux

I. Air-acetylene torch outfit

J. Colored safety glasses

K. Striker

L. 50-50 solder

(NOTE: If 50-50 solder is not available, ask the instructor for a substitute soft solder.)

M. Wood block

N. Clean damp towel

O. Hacksaw

II. Procedure

A. Make a swage joint

B. Remove tubing from the flaring block

C. Use sand cloth to clean the swage socket

JOB SHEET #1

D. Clean one end of the other piece of tubing

E. Do not touch cleaned surfaces

(NOTE: Oils and moisture from the skin would cause the cleaned surfaces to oxidize.)

F. Apply a thin film of flux to the piece to be inserted with a clean brush

(CAUTION: Do not apply flux with fingers. Flux could easily be carried to the eyes which would be very harmful.)

G. Insert tube into swage socket

H. Insert tube until it reaches the bottom of the swage socket

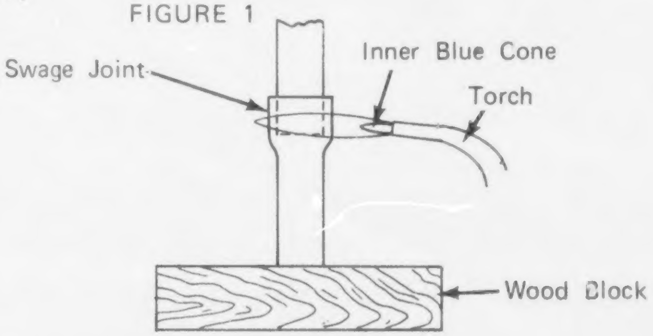
I. Twist the tube while inserting to spread the flux evenly

J. Clean away excess flux with a clean towel

K. Place tubing in wood block (Figure 1)

(NOTE: A wood block approximately 2" x 4" x 6" with various sizes of holes provides an adequate holding device for tubing projects. If a vise is used to hold the tubing, the swage joint should be well above the vise jaws. The vise jaws will absorb heat and make a successful solder joint difficult.)

FIGURE 1



L. Put on colored safety glasses

M. Light and adjust torch

N. Apply heat to swage joint (Figure 1)

(NOTE: The inner blue cone of the flame should be approximately 1/8" away from the swage joint.)

JOB SHEET #1

O. Move the torch around heating the entire joint

P. Apply solder to the joint

(NOTE: Do not melt solder with torch. When the tubing has been heated to the proper temperature the solder will melt and flow into the swage joint.)

(CAUTION: Overheating of tubing can cause solder to splash when applied.)

Q. Discontinue heat and solder application when solder flows from the joint

(NOTE: Do not continue to apply solder if it is not flowing into the joint. If the solder will not flow into the joint it will have to be disassembled, cleaned and the soldering process repeated.)

R. Turn off torch

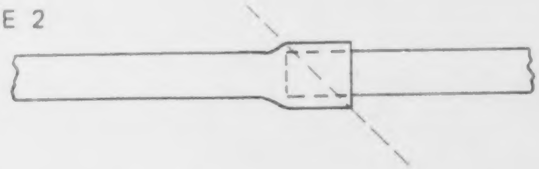
S. Allow solder to cool

T. Clean the joint with a clean damp towel

U. Have instructor inspect

V. Cut swage joint at a diagonal with a hacksaw (Figure 2)

FIGURE 2



W. Have instructor inspect the cut joint

X. Clean up area and put away tools if this is the last soldering project of the day

SOFT SOLDERING
UNIT II

JOB SHEET #2--SOLDER AN INVERTED SWAGE JOINT

I. Tools and materials

- A. Air-acetylene torch outfit
- B. Colored safety glasses
- C. Striker
- D. Tubing
- E. 50-50 solder

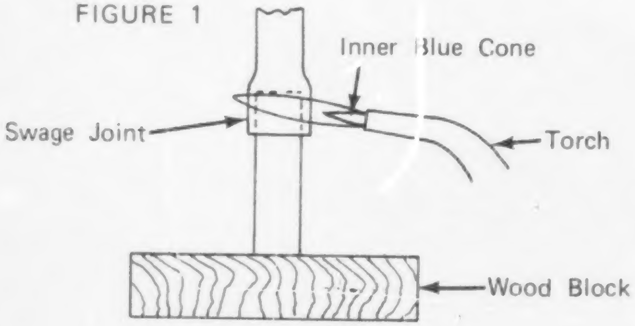
  (NOTE: If 50-50 solder is not available, ask the instructor for a substitute soft solder.)

- F. Wood block
- G. Clean damp towel
- H. Hacksaw

II. Procedure

- A. Prepare and swage tubing
- B. Place tubing in wood block (Figure 1)

FIGURE 1



- C. Put on safety glasses
- D. Light and adjust torch

JOB SHEET #2

E. Apply heat to swage joint (Figure 1)

(NOTE: The inner blue cone of the flame should be approximately 1/8" away from the swage joint.)

F. Move the torch around, heating the entire joint

(NOTE: The heat should be applied on the upper part of the swage joint so that the capillary action will pull the solder up into the joint.)

G. Apply solder to the joint

(NOTE: Do not melt solder with torch. When the tubing has been heated to the proper temperature the solder will melt and flow into the swage joint.)

(CAUTION: Overheating of the tubing can cause solder to splash when applied.)

H. Discontinue heat and solder application when solder flows from the joint

(NOTE: Do not continue to apply solder if it is not flowing into the joint. If the solder will not flow into the joint it will have to be disassembled, cleaned, and the soldering process repeated.)

I. Turn off torch

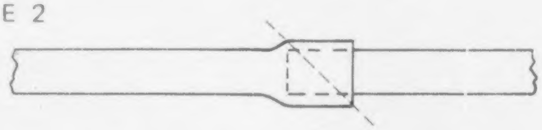
J. Allow solder to cool

K. Clean the joint with a clean damp towel

L. Have instructor inspect

M. Cut swage joint at a diagonal with a hacksaw (Figure 2)

FIGURE 2



N. Have instructor inspect the cut joint

O. Clean up area and put away tools if this is the last soldering project of the day

SOFT SOLDERING
UNIT II

JOB SHEET #3--SOLDER A HORIZONTAL SWAGE JOINT

I. Tools and materials

  A. Air-acetylene torch outfit

  B. Colored safety glasses

  C. Striker

  D. Tubing

  E. 50-50 solder

  (NOTE: If 50-50 solder is not available, ask the instructor for a substitute soft solder.)

  F. Wood block

  G. Clean damp towel

  H. Hacksaw

II. Procedure

  A. Cut three pieces of tubing 3" long

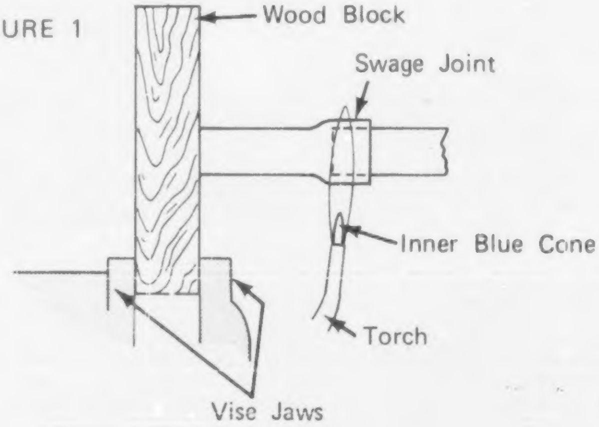
  B. Ream one end of two pieces

  C. Swage the two reamed pieces

  D. Clean, flux, and assemble the pieces of tubing

  E. Place tubing in block (Figure 1)

FIGURE 1



JOB SHEET #3

F. Put on safety glasses

G. Light and adjust torch

H. Apply heat to swage joint (Figure 1)

(NOTE: The inner blue cone of the flame should be approximately 1/8" away from the swage joint.)

I. Move the torch around, heating the entire joint

J. Apply solder to the joint

(NOTE: Do not melt solder with torch. When the tubing has been heated to the proper temperature the solder will melt and flow into the swage joint.)

(CAUTION: Overheating of the tubing can cause solder to splash when applied.)

K. Discontinue heat and solder application when solder flows from the joint

(NOTE: Do not continue to apply solder if it is not flowing into the joint. If the solder will not flow into the joint it will have to be disassembled, cleaned, and the soldering process repeated.)

L. Turn off torch

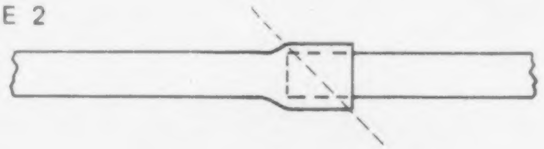
M. Allow solder to cool

N. Clean the joint with a clean damp towel

O. Have instructor inspect

P. Cut swage joint at a diagonal with a hacksaw (Figure 2)

FIGURE 2



Q. Have instructor inspect the cut joint

R. Clean up area and put away tools if this is the last soldering project of the day

SOFT SOLDERING
UNIT II

JOB SHEET #4--SOFT SOLDER WITH THE OXYACETYLENE TORCH

I. Tools and materials

  A. Oxyacetylene torch outfit

  B. Colored safety glasses

  C. Striker

  D. Tubing

  E. 50-50 solder

  (NOTE: If 50-50 solder is not available, ask the instructor for a substitute soft solder.)

  F. Wood block

  G. Clean damp towel

II. Procedure

  A. Cut two pieces of tubing 3" long

  B. Ream one end of one piece

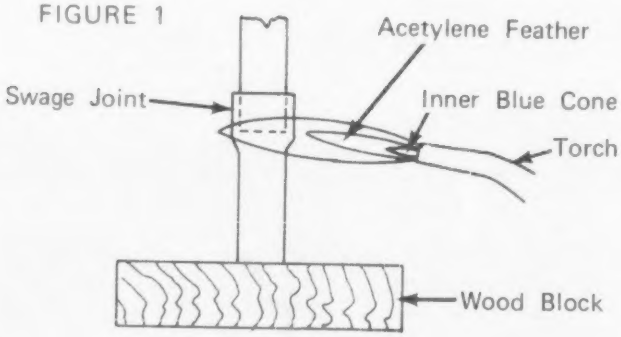
  C. Swage the reamed end of the tubing

  D. Clean, flux, and assemble the pieces of tubing

  E. Place tubing in block (Figure 1)

  (NOTE: If a vise is used to hold the tubing, the swage joint should be well above the vise jaws. The vise jaws will absorb heat and make a successful solder joint difficult.)

FIGURE 1



JOB SHEET #4

F. Put on safety glasses

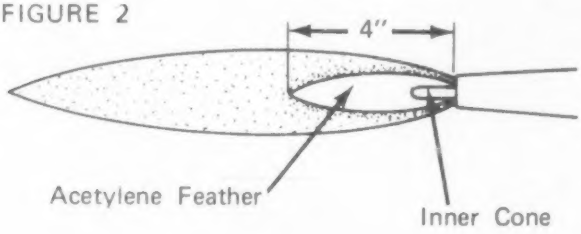
G. Light and adjust torch for neutral flame

H. After obtaining neutral flame add more acetylene (Figure 2)

(NOTE: For soft soldering the acetylene feather should be about 4" long.)

I. Use the acetylene feather for soldering

FIGURE 2



J. Apply heat to swage joint

K. Move the torch around, heating the entire joint

L. Apply solder to the joint

(NOTE: Do not melt solder with torch. When the tubing has been heated to the proper temperature, the solder will melt and flow into the swage joint.)

(CAUTION: Overheating of the tubing can cause solder to splash when applied.)

M. Discontinue heat and solder application when solder flows from the joint

(NOTE: Do not continue to apply solder if it is not flowing into the joint. If the solder will not flow into the joint it will have to be disassembled, cleaned, and the soldering process repeated.)

N. Remove the heat as soon as the solder flows into the joint

O. Turn off torch

P. Allow solder to cool

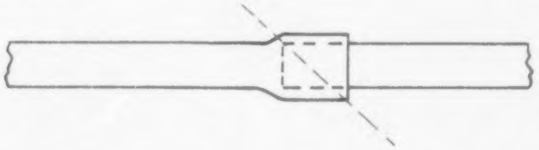
Q. Clean the joint with a clean damp towel

JOB SHEET #4

R. Have instructor inspect

S. Cut swage joint at a diagonal with a hacksaw (Figure 3)

FIGURE 3



T. Have instructor inspect the cut joint

U. Clean up area and put away tools

SOFT SOLDERING
UNIT II

TEST

1. Match the terms on the right to the correct definitions.

_____a. The process of melting a solder on top of the one that was used to make the joint to insure a leak proof joint

_____b. Solder having a low melting point

_____c. To combine with oxygen

_____d. Metal which is melted and is used to join two similar or dissimilar metals together

_____e. Mildly corrosive substance that is applied to a joint prior to soldering to prevent oxidation

_____f. Solder with a melting temperature of 800°F or less, that is used as a filler metal

_____g. Alloy which is added to soft solder for added strength

_____h. The manner in which the molten solder is drawn into the joint through the proper application of heat

1. Flux
2. Eutectic solder
3. Soft solder
4. Antimony
5. Oxidize
6. Topped
7. Filler metal
8. Capillary action

2. Discuss the descriptions and uses of types of soft solder.

a. 50-50

b. 95-5

c. 40-60

d. 63-37

e. 97-3

3. List the thirteen steps in making a solder joint.

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

k.

l.

m.

4. Describe the types of flux used in soft soldering.

   a. Mildly corrosive paste flux

   b. Liquid self-cleaning fluxes

5. List five conditions for creating capillary action of solders.

   a.

   b.

   c.

   d.

   e.

6. Demonstrate the ability to:

   a. Clean, flux, and solder a swage joint.

   b. Solder an inverted swage joint.

   c. Solder a horizontal swage joint.

   d. Soft solder with the oxyacetylene torch.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SOFT SOLDERING
UNIT II

ANSWERS TO TEST

1. a. 6
   b. 2
   c. 5
   d. 7
   e. 1
   f. 3
   g. 4
   h. 8
2. Discussion should include:
   a. 50-50 solder
      1) All purpose solder for plumbing
      2) Easy to use
      3) Composition
         a) 50% tin
         b) 50% lead
   b. 95-5 solder
      1) Usually used only when specified
      2) Hard to use
      3) Composition
         a) 95% tin
         b) 5% antimony
   c. 40-60 solder
      1) Will not flow as well as 50-50
      2) Not generally used
      3) Composition
         a) 40% tin
         b) 60% lead

d. 63-37 solder
  1) A eutectic solder
    a) Very strong
    b) Low melting temperature
  2) Used where low melting temperatures are necessary
  3) Composition
    a) 63% tin
    b) 37% lead

e. 97-3 solder
  1) A silver bearing soft solder
    a) Good strength
    b) Excellent flowing qualities
  2) Used for food processing equipment
  3) Composition
    a) 97% tin
    b) 3% silver

3. a. Measure length of tube
  b. Cut tube square
  c. Ream cut end
  d. Clean tube end
  e. Clean fitting socket
  f. Apply flux to tube end
  g. Assemble
  h. Remove excess flux
  i. Vent with dry nitrogen
  j. Apply heat

   - k. Apply solder
   - l. Allow joint to cool
   - m. Clean the joint

4. Description should include:
   - a. Mildly corrosive paste flux
     - 1) Composed of
       - a) Zinc
       - b) Ammonium
     - 2) Aids in easy flowing of solder
   - b. Liquid self-cleaning fluxes
     - 1) Nonuniform cleaning
     - 2) Could create contamination
5. a. Proper joint fit
   - b. Correct heat temperature
   - c. Even heating
   - d. Properly cleaned joint
   - e. Correct flux
6. Performance skills evaluated to the satisfaction of the instructor

SILVER BRAZING
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with silver brazing to the correct definitions. He should also be able to discuss silver solder and the different types of silver brazing alloys. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with silver brazing to the correct definitions.
2. Discuss the types of silver brazing alloys.
3. Discuss silver solder flux.
4. List the characteristics of the flux at different temperature ranges.
5. Arrange in order the steps in using the air-acetylene high temperature wraparound tip for silver brazing.
6. Demonstrate the ability to:
    a. Silver braze an upright swage joint.
    b. Silver braze an inverted swage joint.
    c. Silver braze a horizontal swage joint.
    d. Silver braze a copper to steel joint.
    e. Silver braze a joint while circulating dry nitrogen.
    f. Silver braze the copper tubing project.

SILVER BRAZING
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined i

   G. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Melting and Brazing Ranges

      2. TM 2--Behavior of Flux During the Brazing Cycle

D. Job sheets

   1. Job Sheet #1--Silver Braze an Upright Swage Joint

   2. Job Sheet #2--Silver Braze an Inverted Swage Joint

   3. Job Sheet #3--Silver Braze a Horizontal Swage Joint

   4. Job Sheet #4--Silver Braze a Copper to Steel Joint

   5. Job Sheet #5--Silver Braze a Joint While Circulating Dry Nitrogen

   6. Job Sheet #6--Silver Braze the Copper Tubing Project

E. Test

F. Answers to test

II. References:

A. "Soldering and Brazing: The Mark of the Craftsman." *Refrigeration Service and Contracting.* March 1975, p. 14.

B. *Refrigeration Service, Part I.* Benton Harbor, Michigan: Whirlpool Corp., 1974.

SILVER BRAZING
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Troy ounce--Unit of weight based on a pound being twelve ounces

      (NOTE: Silver brazing alloy is sold by the troy ounce.)

   B. Silver solder flux--White borax paste applied to the tubing prior to silver brazing to prevent oxidation and to aid in the flowing of the silver alloy

   C. Silver solder--Designates a brazing alloy that contains some silver

   D. Silver brazing--Process of joining two metals together with silver alloy which melts in the 1100°F to 1500°F range

   E. AWS number--Number assigned by the American Welding Society to all welding materials in order to provide uniformity between the different brands

   F. Cadmium--Alloy which is added to silver solder and creates toxic fumes when it is melted

      (NOTE: Cadmium free silver brazing alloy is the recommended alloy to use.)

   G. Alloy--Substance made of two or more metals

   H. Sil-phos--Designates the silver brazing alloy which contains 15% silver and the AWS number is BCuP-5

   I. Phos-copper--Designates the silver brazing alloy which contains 5% silver and the AWS number is BCuP-3

II. Types of silver brazing alloys (Transparency 1)

   A. AWS number BAg-1

      1. Alloys

         a. 45% silver

         b. 15% copper

         c. 16% zinc

         d. 24% cadmium

INFORMATION SHEET

2. Characteristics
    a. Melts at 1125°F
    b. Flows at 1145°F
    c. Excellent for steel to copper joints

B. AWS number BCuP-5

1. Alloys
    a. 15% silver
    b. 80% copper
    c. 5% phosphorus
2. Characteristics
    a. Melts at 1185°F
    b. Flows at 1300°F
    c. Most popular for copper to copper joints

C. AWS number BCuP-3

1. Alloys
    a. 5% silver
    b. 89% copper
    c. 6% phosphorus
2. Characteristics
    a. Melts at 1185°F
    b. Flows at 1300°F

(NOTE: BCuP-5 and BCuP-3 work at approximately the same temperature. BCuP-5 is the preferred alloy to use due to the higher silver content which gives added strength to the solder joint. On copper to copper joints these two alloys may be used without flux.)

INFORMATION SHEET

III. Silver solder flux

   A. White borax paste

   B. Apply thin film to tubing after cleaning

   C. Clean off immediately after brazing

   (NOTE: The silver solder flux should be cleaned from the joint with warm water and a rag. If flux is left on the joint it will cause oxidation.)

   D. Don't allow the paste to harden in the jar

   (NOTE: If the flux becomes hard in the jar add a small amount of water and stir. This condition can be prevented by keeping a small amount of water in the jar.)

   E. Apply flux with a clean brush

   F. Flux protects the joint from oxidation during the brazing process

IV. Flux characteristics at different temperature ranges (Transparency 2)

   A. 200°F to 500°F--Water boils out of flux

   B. 600°F to 800°F--Flux will bubble

   C. 1100°F--Flux turns to a clear liquid

   (NOTE: When the flux turns to a clear liquid state this indicates that the brazing range of most alloys has been reached.)

   D. 1600°F and above--Flux will burn and no longer protect the joint

V. Steps in using the air-acetylene high temperature wraparound tip for silver brazing

   A. Place tip in torch handle

   B. Open acetylene cylinder valve half a turn

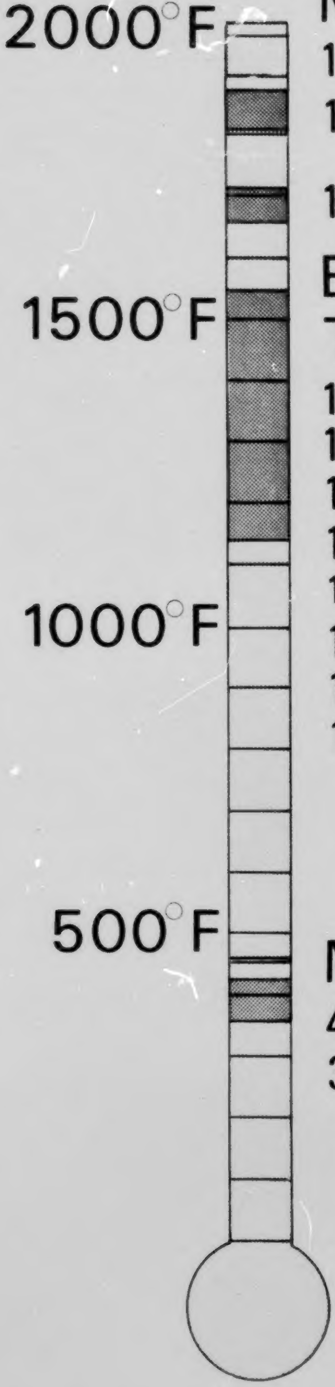
   C. Open torch handle valve

   D. Ignite flame

   E. Immediately upon ignition open torch handle valve all the way

   F. Hold torch so that inner blue flame wraps around the joint

Melting and Brazing Ranges



Melting Range

1981 Copper
1810-1880 Red Brass
1660-1710 Yellow Brass

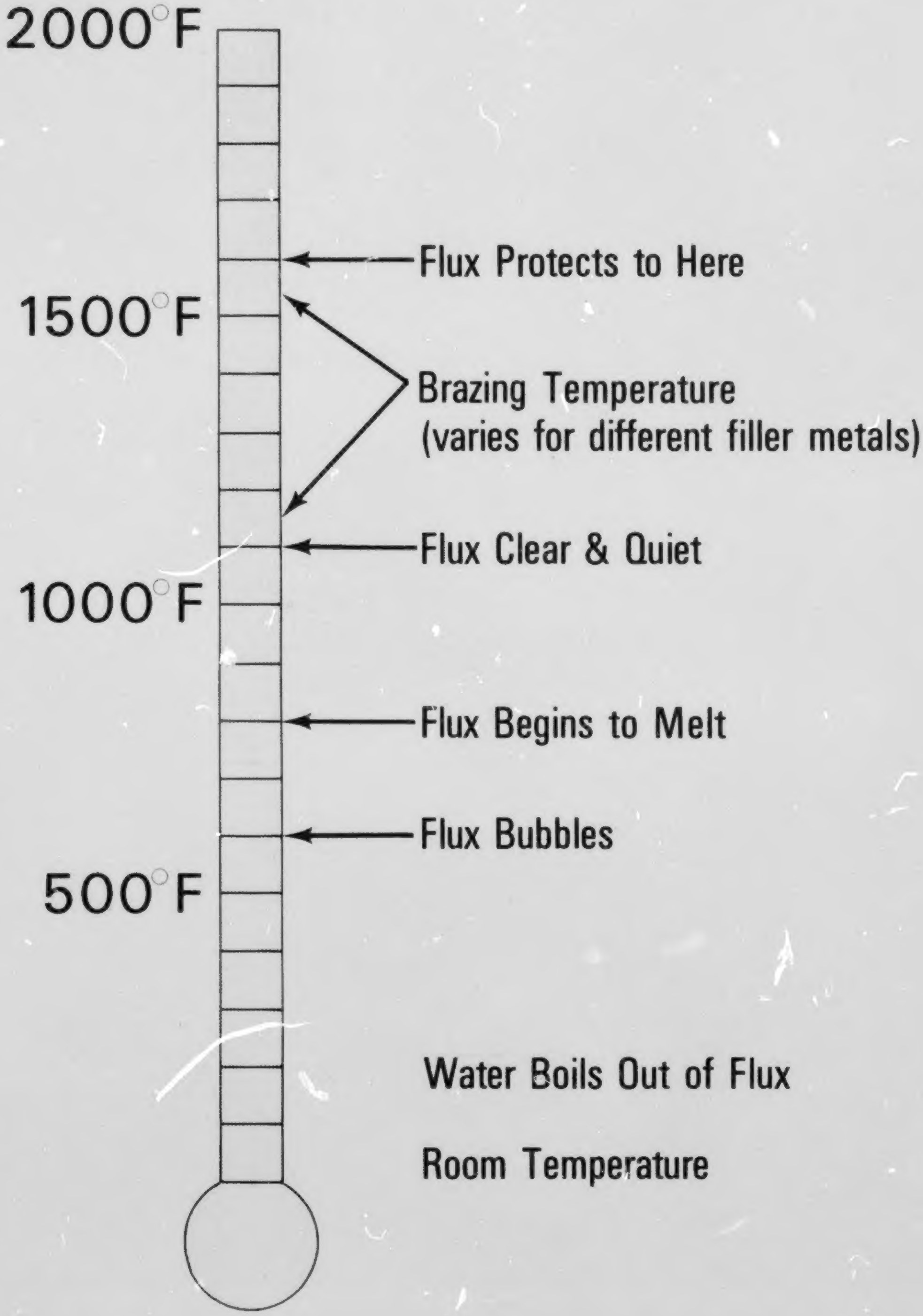
Brazing Temperature Range

1350-1550 BCuP-2 Copper Phos.
1300-1550 BCuP-3 Copper Phos.
1300-1450 BCuP-4 Copper Phos.
1300-1500 BCuP-5 Copper Phos.
1145-1400 BAg-1 Silver
1295-1550 BAg-2 Silver
1370-1550 BAg-5 Silver
1205-1400 BAg-7 Silver

Melting Range-Solders

452-464 95/5 Tin-Antimony
361-421 50/50 Tin-Lead

Behavior of Flux During Brazing Cycle



2000°F

Flux Protects to Here

1500°F

Brazing Temperature
(varies for different filler metals)

Flux Clear & Quiet

1000°F

Flux Begins to Melt

Flux Bubbles

500°F

Water Boils Out of Flux

Room Temperature

SILVER BRAZING
UNIT III

JOB SHEET #1--SILVER BRAZE AN UPRIGHT SWAGE JOINT

I. Tools and materials

   A. Tubing cutter

   B. Reamer

   C. Rule

   D. Flaring block

   E. Swage punch

   F. Ball peen hammer

   G. Oxyacetylene torch outfit with tip #51

   H. Welding goggles

   I. Striker

   J. Clean damp towel

   K. Copper tubing

   L. Sand cloth

   M. Silver solder flux

   N. Silver solder

II. Procedure

   A. Cut two pieces of copper tubing 3" long

   B. Ream one end of one tube

   C. Swage the reamed end

   D. Clean tubing and swage socket with sand cloth

   E. Apply a thin film of flux to tubing

   (NOTE: Use a clean brush to apply flux. Do not use your finger. Wash flux out of brush after use.)

   F. Insert tube into swage socket

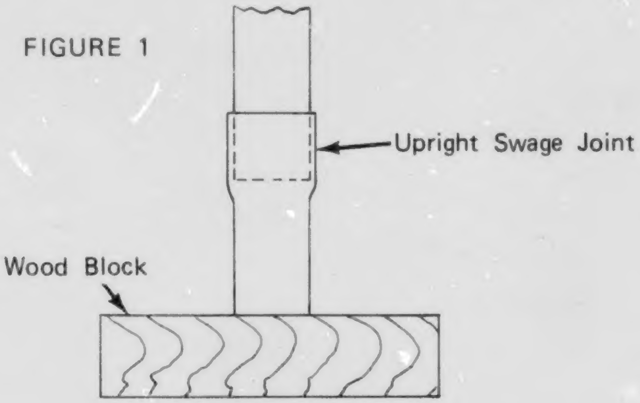
JOB SHEET #1

G. Twist tube while inserting to spread the flux

H. Place assembled swage joint in vise or wood block (Figure 1)

(NOTE: If a vise is used do not place the swage socket down against the jaws. The jaws will absorb heat and cause irratic brazing conditions.)

FIGURE 1



I. Light the oxyacetylene torch

J. Adjust torch for a neutral flame

K. Heat the socket and the tube

L. Continuously move the flame back and forth until both pieces are evenly heated

M. Watch the flux for a heat guide

N. Move the flame to the base of the socket when the flux turns to a liquid state

O. Add the brazing alloy at the point the tube enters the socket

P. Remove the heat as soon as the silver alloy flows completely around the joint

Q. Turn off torch

R. Clean the joint with the damp towel

(NOTE: If flux has already hardened a wire brush may be needed to remove it.)

JOB SHEET #1

S. Have instructor inspect

T. Clean up area

U. Put away tools

SILVER BRAZING
UNIT III

JOB SHEET #2--SILVER BRAZE AN INVERTED SWAGE JOINT

I. Tools and materials

- A. Tubing cutter
- B. Reamer
- C. Rule
- D. Flaring block
- E. Swage punch
- F. Ball peen hammer
- G. Oxyacetylene torch outfit with tip #51
- H. Welding goggles
- I. Striker
- J. Clean damp towel
- K. Copper tubing
- L. Sand cloth
- M. Silver solder flux
- N. Silver solder

II. Procedure

- A. Cut two pieces of copper tubing 3" long
- B. Ream one end of one tube
- C. Swage the reamed end
- D. Clean tubing and swage socket with sand cloth
- E. Apply a thin film of flux to tubing and socket

  (NOTE: Use a clean brush to apply flux with. Do not use your finger. Wash flux out of brush after use.)

JOB SHEET #2

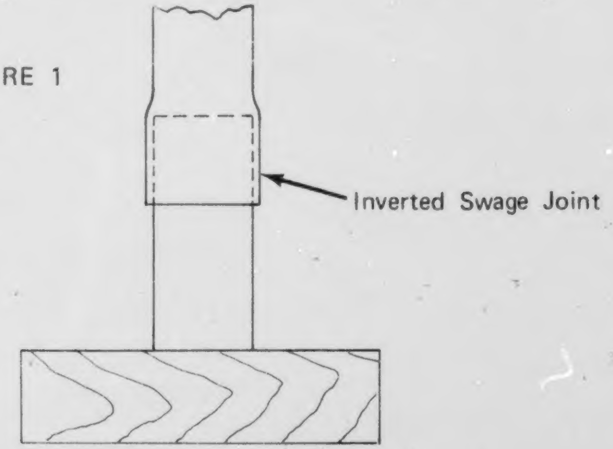
F. Insert tube into swage socket

G. Twist tube while inserting to spread the flux

H. Place assembled swage joint in vise or wood block (Figure 1)

(NOTE: If a vise is used do not place the swage socket down against the jaws. The jaws will absorb heat and cause irratic brazing conditions.)

FIGURE 1



I. Light the oxyacetylene torch

J. Adjust torch for a neutral flame

K. Heat the socket and the tube

L. Continuously move the flame back and forth until both pieces are evenly heated

M. Watch the flux for a heat guide

N. Move the flame to the base of the socket when the flux turns to a liquid state

O. Add the brazing alloy at the point the tube enters the socket

P. Remove the heat as soon as the silver alloy flows completely around the joint

Q. Turn off torch

R. Clean the joint with the damp towel

S. If flux has already hardened a wire brush may be needed to remove it

JOB SHEET #2

T. Have instructor inspect

U. Clean up area

V. Put away tools

SILVER BRAZING
UNIT III

JOB SHEET #3--SILVER BRAZE A HORIZONTAL SWAGE JOINT

I. Tools and materials

  A. Tubing cutter

  B. Reamer

  C. Rule

  D. Flaring block

  E. Swage punch

  F. Ball peen hammer

  G. Oxyacetylene torch outfit with tip #51

  H. Welding goggles

  I. Striker

  J. Clean damp towel

  K. Copper tubing

  L. Sand cloth

  M. Silver solder flux

  N. Silver solder

II. Procedure

  A. Cut two pieces of copper tubing 3" long

  B. Ream one end of one tube

  C. Swage the reamed end

  D. Clean tubing and swage socket with sand cloth

  E. Apply a thin film of flux to tubing and socket

  (NOTE: Use a clean brush to apply flux. Do not use your finger. Wash flux out of brush after use.)

  F. Insert the tube into swage socket

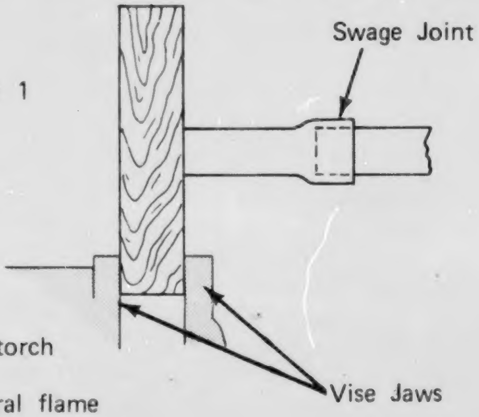
JOB SHEET #3

G. Twist tube while inserting to spread the flux

H. Place assembled swage joint in vise or wood block (Figure 1)

(NOTE: If a vise is used do not place the swage socket down against the jaws. The jaws will absorb heat and cause irratic brazing conditions.)

FIGURE 1



I. Light the oxyacetylene torch

J. Adjust torch for a neutral flame

K. Heat the socket and the tube

L. Continuously move the flame back and forth until both pieces are evenly heated

M. Watch the flux for a heat guide

N. Move the flame to the base of the socket when the flux turns to a liquid state

O. Add the brazing alloy at the point the tube enters the socket

P. Remove the heat as soon as the silver alloy flows completely around the joint

Q Turn off torch

R. Clean the joint with the damp towel

(NOTE: If flux has already hardened, a wire brush may be needed to remove it.)

S. Have instructor inspect

T. Clean up area

U. Put away tools

SILVER BRAZING
UNIT III

JOB SHEET #4--SILVER BRAZE A COPPER TO STEEL JOINT

I. Tools and materials

- A. Tubing cutter
- B. Reamer
- C. Rule
- D. Flaring block
- E. Swage punch
- F. Ball peen hammer
- G. Oxyacetylene torch outfit with tip #51
- H. Welding goggles
- I. Striker
- J. Clean damp towel
- K. Copper tubing
- L. Steel tubing
- M. Sand cloth
- N. Silver-solder flux
- O. Silver solder BAg-1

II. Procedure

- A. Cut a piece of copper tubing 3" long and a piece of steel tubing 3" long
- B. Ream one end of the copper tube
- C. Swage the reamed end

  (NOTE: Swage the copper tube and not the steel tubing. Steel is seam type tubing and it will split if you try to swage it.)
- D. Clean tubing and swage socket with sand cloth

JOB SHEET #4

E. Apply a thin film of flux to tubing

(NOTE: Use a clean brush to apply flux. Do not use your finger. Wash flux out of brush after use.)

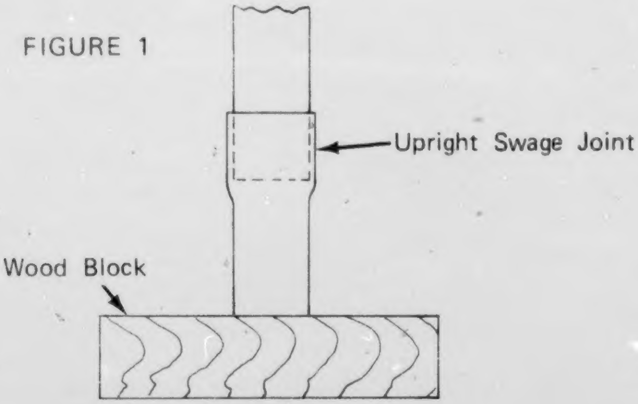
F. Insert tube into swage socket

G. Twist tube while inserting to spread the flux

H. Place assembled swage joint in vise or wood block (Figure 1)

(NOTE: If a vise is used do not place the swage socket down against the jaws. The jaws will absorb heat and cause irratic brazing conditions.)

FIGURE 1



I. Light the oxyacetylene torch

J. Adjust torch for a neutral flame

K. Heat the socket

(NOTE: The heat should be applied to the copper swage socket and not to the steel tubing. Steel tubing will overheat before the copper tubing is hot enough to melt the silver alloy.)

L. Continuously move the flame back and forth until both pieces are evenly heated

M. Watch the flux for a heat guide

N. Move the flame to the base of the socket when the flux turns to a liquid state

O. Add the brazing alloy at the point the tube enters the socket

JOB SHEET #4

P. Remove the heat as soon as the silver alloy flows completely around the joint

Q. Turn off torch

R. Clean the joint with the damp towel

(NOTE: If flux has already hardened a wire brush may be needed to remove it.)

S. Have instructor inspect

T. Clean up area

U. Put away tools

SILVER BRAZING
UNIT III

JOB SHEET #5--SILVER BRAZE A JOINT WHILE CIRCULATING DRY NITROGEN

I. Tools and materials

A. Tubing cutter

B. Reamer

C. Rule

D. Flaring block

E. Swage punch

F. Ball peen hammer

G. Oxyacetylene torch outfit with tip #51

H. Welding goggles

I. Striker

J. Clean damp towel

K. Dry nitrogen cylinder with regulator

L. Copper tubing

M. Sand cloth

N Silver solder flux

O. Silver solder BCuP-5

II. Procedure

A. Cut two pieces of copper tubing 3" long

B. Ream one end of one tube

C. Swage the reamed end

D. Clean tubing and swage socket with sand cloth

E. Insert tube into swage socket

JOB SHEET #5

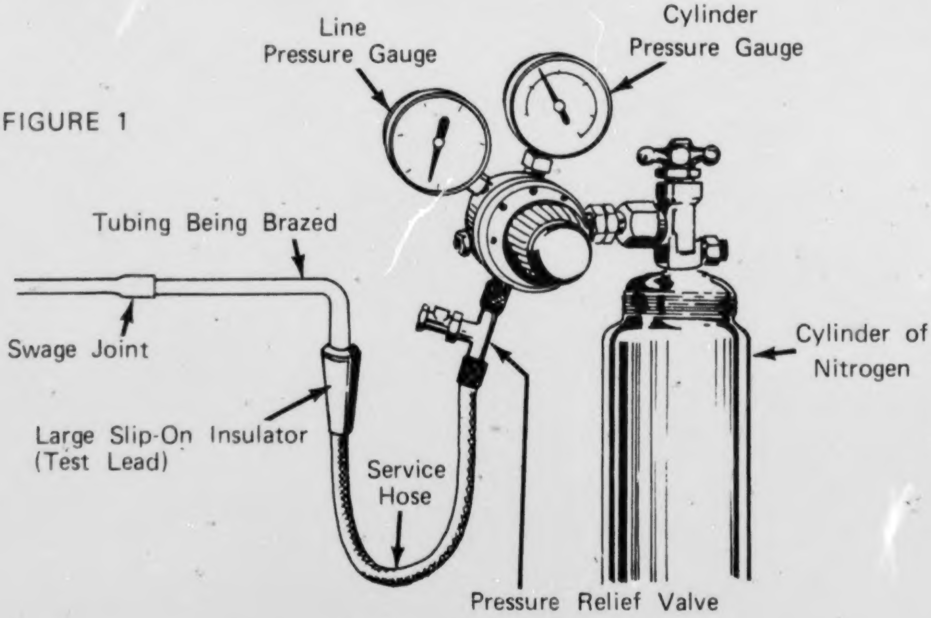
F. Place assembled swage joint in vise or wood block

(NOTE: If a vise is used do not place the swage socket down against the jaws. The jaws will absorb heat and cause irratic brazing conditions.)

G. Attach nitrogen cylinder to tubing to be brazed (Figure 1)

(NOTE: A damp towel may need to be wrapped around the hose where it connects onto the tubing to prevent damage to it from conducted heat.)

FIGURE 1


Line Pressure Gauge
Cylinder Pressure Gauge
Tubing Being Brazed
Swage Joint
Cylinder of Nitrogen
Large Slip-On Insulator (Test Lead)
Service Hose
Pressure Relief Valve

H. Set nitrogen regulator at 2 p.s.i.g. and circulate nitrogen through the tubing while brazing

(NOTE: If the use of the nitrogen cylinder has not been explained prior to this ask the instructor for assistance.)

I. Light the oxyacetylene torch

J. Adjust torch for a neutral flame

K. Heat the socket and the tube

L. Continuously move the flame back and forth until both pieces are evenly heated

M. Add the brazing alloy at the point the tube enters the socket

JOB SHEET #5

N. Remove the heat as soon as the silver alloy flows completely around the joint

O. Turn off torch

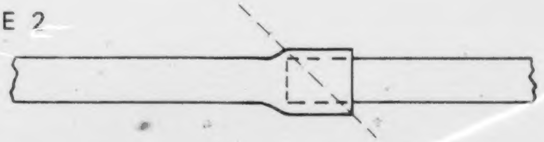
P. Close nitrogen cylinder valve

Q. Remove nitrogen hose from tubing

R. Allow tubing to cool

S. Cut tubing and tubing from Job Sheet #3 at a diagonal (Figure 2)

FIGURE 2



T. Compare the amount of oxidation formed in the tube from Job Sheet #3 as compared to the one brazed with the nitrogen being circulated

U. Have the instructor inspect

V. Clean up area

W. Put away tools

SILVER BRAZING
UNIT III

JOB SHEET #6--SILVER BRAZE THE COPPER TUBING PROJECT

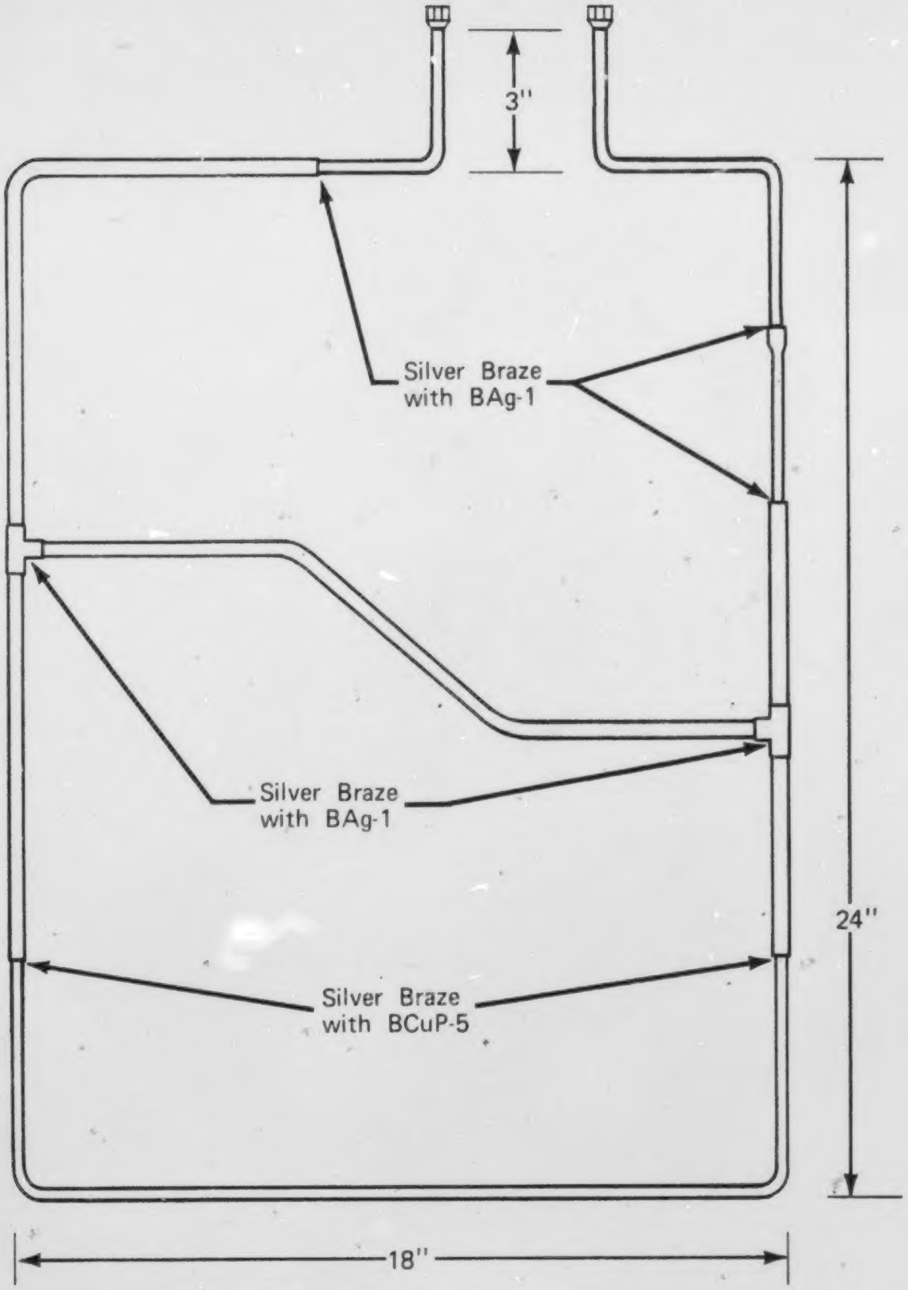
I. Tools and materials

- A. Oxyacetylene torch
- B. Welding goggles
- C. Striker
- D. Clean damp towel
- E. Tubing project from Tubing Operations unit, Job Sheet #9
- F. Sand cloth
- G. Silver solder flux
- H. Silver solder BAg-1 and BCuP-5

II. Procedure

- A. Use BAg-1 solder on all tee joints
- B. Clean tee joints
- C. Flux the tee joints
- D. Assemble the tubing project
- E. Place tubing project in vise
- F. Light the oxyacetylene torch
- G. Adjust the torch for a neutral flame
- H. Heat the tee and the tubing
- I. Continuously move the flame back and forth until the tee and the tubing are evenly heated
- J. Watch the flux for a heat guide
- K. Move the flame to the tee when the flux turns to a liquid state
- L. Add the brazing alloy (BAg-1) at the point where the tube enters the tee

JOB SHEET #6


3"
Silver Braze with BAg-1
Silver Braze with BAg-1
Silver Braze with BCuP-5
24"
18"

Scale: 1/4"=1"

JOB SHEET #6

M. Move quickly and braze all three points simultaneously (NOTE: Too much delay will cause the tee to overheat.)

N. Silver braze the other tee joint

O. Braze the other joints with BCuP-5 (Sil-phos)

P. Turn off the torch

Q. Remove the flux residue from the tee joints

R. Allow tubing to cool

S. Install 1/4" flare unions in the flare nuts

T. Pressurize to 50 p.s.i.g. and check for leaks

U. Have the instructor inspect

V. Clean up area

W. Put away tools

SILVER BRAZING
UNIT III

TEST

1. Match the terms on the right to the correct definitions.

______a. Designates the silver brazing alloy which contains 5% silver and the AWS number is BCuP-3

______b. Designates the silver brazing alloy which contains 15% silver and the AWS number is BCuP-5

______c. Substance made of two or more metals

______d. Alloy which is added to silver solder and creates toxic fumes when it is melted

______e. Number assigned by the American Welding Society to all welding materials in order to provide uniformity between the different brands

______f. Process of joining two metals together with silver alloy which melts in the 1100°F to 1500°F range

______g. Designates a brazing alloy that contains some silver

______h. White borax paste applied to the tubing prior to silver brazing to prevent oxidation and to aid in the flowing of the silver alloy

______i. Unit of weight based on a pound being twelve ounces

1. Alloy
2. Phos-copper
3. Silver brazing
4. Troy ounce
5. Silver solder
6. Silver solder flux
7. AWS number
8. Cadmium
9. Sil-phos

2. Discuss the types of silver brazing alloys.

   a. AWS number BAg-1

   b. AWS number BCuP-5

   c. AWS number BCuP-3

3. Discuss silver solder flux.

4. List the characteristics of the flux at different temperature ranges.

   a. 200°F to 500°F--

   b. 600°F to 800°F--

   c. 1100°F--

   d. 1600°F and above--

5. Arrange in order the following steps in using the air-acetylene high temperature wraparound tip for silver brazing by placing the correct sequence number in the appropriate blank.

   ______a. Immediately upon ignition open torch handle valve all the way

   ______b. Place tip in torch handle

   ______c. Open acetylene cylinder valve half a turn

   ______d. Open torch handle valve

   ______e. Ignite flame

   ______f. Hold torch so that inner blue flame wraps around the joint

6. Demonstrate the ability to:

   a. Silver braze an upright swage joint.

   b. Silver braze an inverted swage joint.

   c. Silver braze a horizontal swage joint.

   d. Silver braze a copper to steel joint.

   e. Silver braze a joint while circulating dry nitrogen.

   f. Silver braze the copper tubing project.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

SILVER BRAZING
UNIT III

ANSWERS TO TEST

1. a. 2
   b. 9
   c. 1
   d. 8
   e. 7
   f. 3
   g. 5
   h. 6
   i. 4

2. Discussion should include:
   a. AWS number BAg-1
      1) Alloys
         a) 45% silver
         b) 15% copper
         c) 16% zinc
         d) 24% cadmium
      2) Characteristics
         a) Melts at 1125°F
         b) Flows at 1145°F
         c) Excellent for steel to copper joints
   b. AWS number BCuP-5
      1) Alloys
         a) 15% silver
         b) 80% copper
         c) 5% phosphorus
      2) Characteristics
         a) Melts at 1185°F
         b) Flows at 1300°F
         c) Most popular for copper to copper joints

- c. AWS number BCuP-3
    - 1) Alloys
        - a) 5% silver
        - b) 89% copper
        - c) 6% phosphorus
    - 2) Characteristics
        - a) Melts at 1185°F
        - b) Flows at 1300°F

3. Discussion should include:
    - a. White borax paste
    - b. Apply thin film to tubing after cleaning
    - c. Clean off immediately after brazing
    - d. Don't allow the paste to harden in the jar
    - e. Apply flux with a clean brush
    - f. Flux protects the joint from oxidation during the brazing process

4. a. Water boils out of flux
    - b. Flux will bubble
    - c. Flux turns to a clear liquid
    - d. Flux will burn and no longer protect the joint

5. a. 5
    - b. 1
    - c. 2
    - d. 3
    - e. 4
    - f. 6

6. Performance skills evaluated to the satisfaction of the instructor

ALUMINUM SOLDERING
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with aluminum soldering to the correct definitions and list the types of torches and the steps for using the aluminum brazing rod and aluminum soft solder. The student should also be able to select from a group the proper flame to use when aluminum soldering. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with aluminum soldering to the correct definitions.
2. List three torches used in the field for aluminum soldering.
3. Select the proper flame to use when soldering aluminum.
4. List eight steps for using the aluminum brazing rod.
5. List nine steps for using aluminum soft solder.
6. Demonstrate the ability to:
    a. Solder aluminum tubing.
    b. Solder aluminum tubing to copper tubing.
    c. Aluminum braze a hole in aluminum tubing.

ALUMINUM SOLDERING
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparency.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Demonstrate proper torch flame adjustment.

   H. Install fittings on some old aluminum evaporators so they can be pressurized after they are soldered.

   I. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency master: TM 1--Soft Reducing Flame

D. Job sheets

  1. Job Sheet #1--Solder Aluminum Tubing

  2. Job Sheet #2--Solder Aluminum Tubing to Copper Tubing

  3. Job Sheet #3--Aluminum Braze a Hole in Aluminum Tubing

E. Test

F. Answers to test

II. References:

A. *Field Repair of Aluminum Refrigeration Coils.* Des Plaines, Illinois: The Aluminum Association, 1972.

B. *Brazing and Soldering Manual,* Form No. 22565. White Plains, New York: All-State Welding Alloys Co., Inc., 1964.

ALUMINUM SOLDERING
UNIT IV

INFORMATION SHEET

I. Terms and definitions

   A. Aluminum--Bluish-white metal that is soft and easy to form into shapes; it has a high conductivity rate and is the earth's most plentiful metal

   B. Anodize--To coat metal with a protective coating

   C. Aluminum brazing--Procedure for repairing aluminum using an aluminum alloy rod which melts at a temperature around 1050°F

   D. Aluminum soldering--Procedure for repairing aluminum using a soft wire solder which melts at a temperature around 500°F

   E. Aluminum soldering flux--Mildly corrosive chemical which is different for each type of aluminum soldering or brazing

II. Torches used in the field for aluminum soldering

   A. Air-propane

   B. Air-acetylene

   C. Oxyacetylene

III. Proper flame to use when soldering aluminum (Transparency 1)

   A. Soft reducing flame

   B. Slight excess of acetylene

   C. Medium length pointed inner cone

   D. Light blue outer envelope

IV. Steps for using aluminum brazing rod

   A. Clean surface

   (NOTE: If the aluminum is anodized, the anodizing must be removed.)

   B. Warm the rod end

INFORMATION SHEET

C. Dip warmed end into flux

D. Melt flux off of rod onto joint or area to be brazed

E. Keep torch in motion and heat rapidly until flux turns liquid

F. Melt rod onto the aluminum while keeping the flame on the fluxed area

G. Allow the solder to cool

H. Remove flux residue with warm water and a clean cloth

(NOTE: When working on a refrigeration system have pressure on the system while cleaning the repaired area. This will prevent water from entering the system if a leak still exists.)

V. Steps for using aluminum soft solder

(NOTE: Aluminum soft solder is generally used when joining two pieces of aluminum tubing or when joining aluminum to copper tubing.)

A. Clean the tubing

B. Apply a small amount of flux to joint area

(NOTE: This type of flux will generally be liquid.)

C. Dip end of solder in flux

D. Apply heat above and below joint constantly moving the torch back and forth

E. Do not apply flame directly to the flux

F. Continue to dip the solder in the flux while applying it to the joint

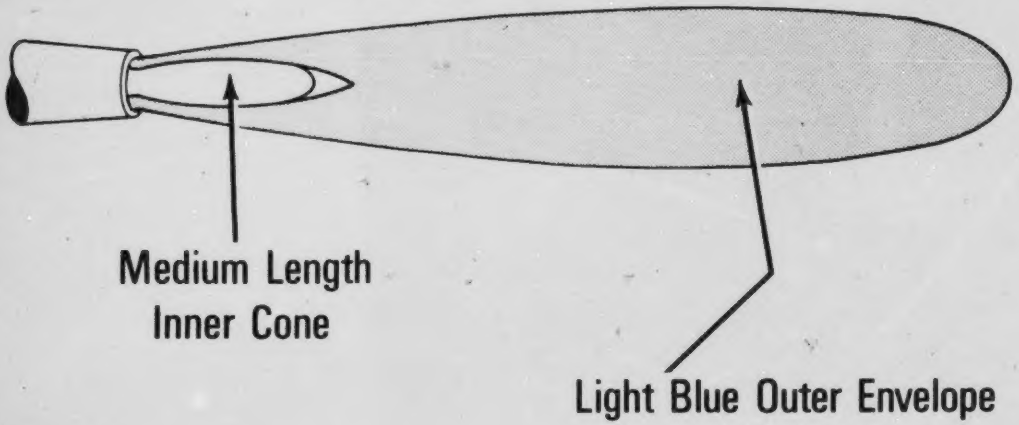
G. Continue to move the torch during the entire process

(NOTE: If the flux burns, stop, disassemble joint, clean, and start over.)

H. Allow joint to cool

I. Remove flux residue with hot water and clean cloth

Soft Reducing Flame


Medium Length
Inner Cone
Light Blue Outer Envelope

ACR I - 127-E

ALUMINUM SOLDERING
UNIT IV

JOB SHEET #1--SOLDER ALUMINUM TUBING

I. Tools and materials

A. Air-propane torch

B. Air-acetylene torch

C. Oxyacetylene torch

D. Tubing cutter

E. Reamer

F. Flaring block

G. Swage punch

H. Ball peen hammer

I. Colored safety glasses

J. Aluminum tubing

K. Sand cloth

L. Aluminum soft solder

M. Flux

N. Clean towel

O. Hacksaw

II. Procedure

A. Cut two pieces of aluminum tubing 3" long

B. Ream one end of one piece

(NOTE: Be careful not to over-ream and make the tubing wall too thin.)

C. Place the reamed piece of tubing in the flaring block

D. Swage the piece of tubing

E. Remove the tubing from the flaring block

JOB SHEET #1

F. Clean the swage socket

G. Clean one end of the piece of tubing

H. Apply a small amount of flux to the tubing end that will be inserted into the swage

I. Insert tubing into swage socket

J. Twist tubing while inserting to aid in the even spreading of the flux

K. Place assembled tubing in a holding device

(NOTE: Since heat is very critical when working with aluminum, a wood block makes an excellent holding device.)

L. Light the torch

M. Adjust for a soft reducing flame

N. Dip one end of solder into flux

O. Apply heat above and below joint constantly moving the torch back and forth

(CAUTION: Do not apply flame directly to the flux. Fumes that will be emitted from the flux should not be inhaled.)

P. Continue to touch the solder to the joint until it flows around the joint

Q. Dip the solder in the flux every so often during the soldering process

R. Continue to move the torch from above the swage joint to below it

S. Remove heat when solder has flowed all the way around the joint

T. Turn off torch

U. Allow joint to cool for a moment

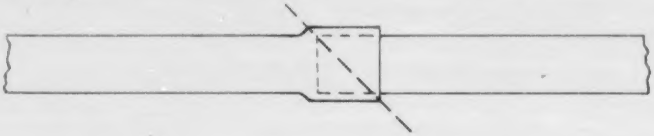
V. Remove flux residue with hot water and a clean towel

W. Have instructor inspect

JOB SHEET #1

X. Cut swage joint at a diagonal with a hacksaw (Figure 1)

FIGURE 1



Y. Have instructor inspect the cut joint

Z. Clean area and put away tools if this is the last soldering project of the day

ALUMINUM SOLDERING
UNIT IV

JOB SHEET #2--SOLDER ALUMINUM TUBING TO COPPER TUBING

I. Tools and materials

   A. Air-propane torch

   B. Air-acetylene torch

   C. Oxyacetylene torch

   D. Tubing cutter

   E. Reamer

   F. Flaring block

   G. Swage punch

   H. Ball peen hammer

   I. Colored safety glasses

   J. Aluminum tubing

   K. Copper tubing

   L. Sand cloth

   M. Aluminum brazing rod

   N. Flux

   O. Clean damp towel

   P. Hacksaw

II. Procedure

   A. Cut a piece of aluminum tubing 3" long

   B. Cut a piece of copper tubing 3" long

   C. Ream one end of the copper tubing

   D. Place the copper tubing in the flaring block

   E. Swage the reamed end

   F. Remove tubing from the flaring block

JOB SHEET #2

G. Clean the swage socket

H. Clean one end of the aluminum tubing

I. Apply a small amount of flux to the aluminum tubing

J. Insert tubing into swage socket

K. Twist tubing while inserting to aid in the even spreading of the flux

L. Place assembled tubing in a holding device

M. Light the torch

N. Adjust for a soft reducing flame

O. Dip one end of solder into flux

P. Apply heat above and below joint constantly moving the torch back and forth

(CAUTION: Do not apply flame directly to the flux. Fumes that will be emitted from the flux should not be inhaled.)

Q. Continue to touch the solder to the joint until it flows

R. Keep the flame on the copper swage socket when the solder begins to flow

S. Remove the heat when the solder has flowed all the way around the joint

T. Turn off torch

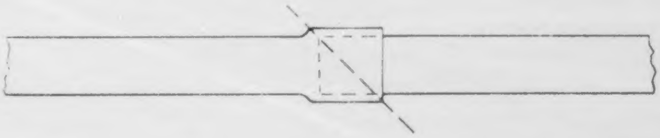
U. Allow solder to cool

V. Clean the joint with a clean damp towel

W. Have instructor inspect

X. Cut swage joint at a diagonal with a hacksaw (Figure 1)

FIGURE 1



JOB SHEET #2

Y. Have instructor inspect the cut joint

Z. Clean area and put away tools if this is the last soldering project of the day

ALUMINUM SOLDERING
UNIT IV

JOB SHEET #3--ALUMINUM BRAZE A HOLE IN ALUMINUM TUBING

I. Tools and materials

   A. Air-acetylene torch

   B. Oxyacetylene torch

   C. Tubing cutter

   D. Scratch awl

   E. Aluminum tubing or scrap aluminum heat exchanger

   F. Sand cloth

   G. Aluminum brazing rod

   H. Flux

II. Procedure

   A. Punch a hole with a scratch awl in the aluminum piece to be brazed

   B. Clean the surface

   (NOTE: If an aluminum heat exchanger is being brazed, tilt it slightly so that any traces of oil in it will not collect at the heat area.)

   C. Warm one end of the brazing rod

   D. Dip warmed end into the flux

   E. Melt flux off of rod onto area to be brazed

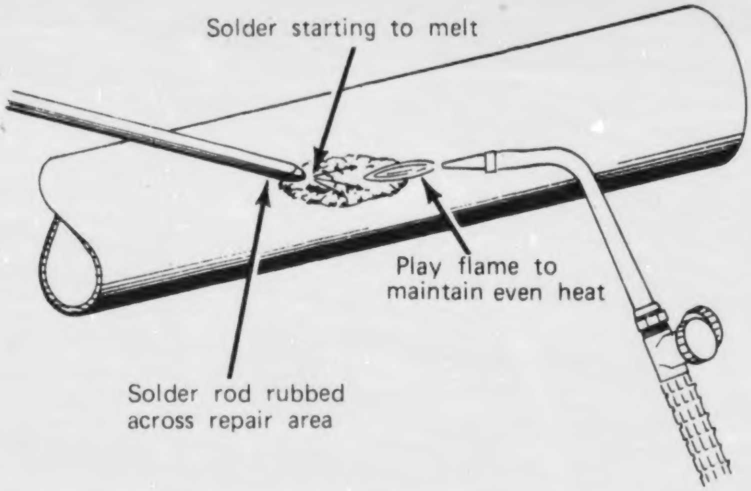
   F. Keep torch in motion and heat rapidly until flux turns liquid

   G. Melt rod onto the aluminum while keeping the flame on the fluxed area

JOB SHEET #3

H. Scratch the area with the rod as the solder begins to melt (Figure 1)

FIGURE 1


Solder starting to melt
Play flame to maintain even heat
Solder rod rubbed across repair area

I. Keep the torch in motion until the entire area to be repaired is covered

J. Allow the solder to cool

K. Remove the flux residue with warm water and a clean cloth

(NOTE: If a heat exchanger was used for the project, it might be necessary to pressurize it and check for leaks.)

L. Have the instructor inspect

M. Clean area and put away tools

ALUMINUM SOLDERING
UNIT IV

TEST

1. Match the terms on the right to the correct definitions.

______a. Bluish-white metal that is soft and easy to form into shapes; it has a high conductivity rate and is the earth's most plentiful metal

______b. Procedure for repairing aluminum using a soft wire solder which melts at a temperature around 500°F

______c. Mildly corrosive chemical which is different for each type of aluminum soldering or brazing

______d. To coat metal with a protective coating

______e. Procedure for repairing aluminum using an aluminum alloy rod which melts at a temperature around 1050°F

1. Anodize
2. Aluminum brazing
3. Aluminum
4. Aluminum soldering
5. Aluminum soldering flux

2. List three torches used in the field for aluminum soldering.

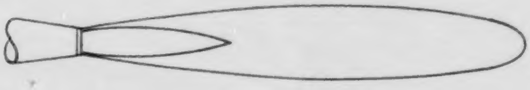
a.

b.

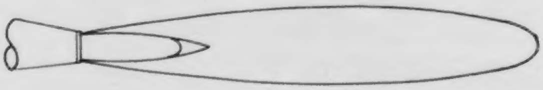
c.

3. Select the proper flame to use when soldering aluminum by placing an "X" in the appropriate blank.

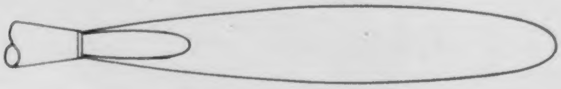
______a. Strong Reducing Flame



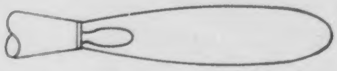
______b. Soft Reducing Flame



______c. Neutral Flame



______d. Oxidizing Flame



4. List eight steps for using the aluminum brazing rod.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

5. List nine steps for using aluminum soft solder.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

   i.

6. Demonstrate the ability to:

   a. Solder aluminum tubing.

   b. Solder aluminum tubing to copper tubing.

   c. Aluminum braze a hole in aluminum tubing.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

ALUMINUM SOLDERING
UNIT IV

ANSWERS TO TEST

1. a. 3
   b. 4
   c. 5
   d. 1
   e. 2
2. a. Air-propane
   b. Air-acetylene
   c. Oxyacetylene
3. b
4. a. Clean surface
   b. Warm the rod end
   c. Dip warmed end into flux
   d. Melt flux off of rod onto joint or area to be brazed
   e. Keep torch in motion and heat rapidly until flux turns liquid
   f. Melt rod onto the aluminum while keeping the flame on the fluxed area
   g. Allow the solder to cool
   h. Remove flux residue with warm water and a clean cloth
5. a. Clean the tubing
   b. Apply a small amount of flux to joint area
   c. Dip end of solder in flux
   d. Apply heat above and below joint constantly moving the torch back and forth
   e. Do not apply flame directly to the flux

   f. Continue to dip the solder in the flux while applying it to the joint

   g. Continue to move the torch during the entire process

   h. Allow joint to cool

   i. Remove flux residue with hot water and clean cloth

6. Performance skills evaluated to the satisfaction of the instructor

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to light, adjust, and turn off an oxyacetylene cutting outfit. He should also be able to make ninety degree cuts and cut holes in mild steel. In addition, he should be able to select the proper size welding tip and to choose the correct filler rod. He should be able to demonstrate the ability to do fusion welding with or without filler rod. He should be able to list the advantages and disadvantages of brazing. He should be able to demonstrate the ability to apply flux to a filler rod and construct a butt weld using the brazing process. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with oxyacetylene cutting, welding, and brazing to the correct definitions.
2. Identify the parts of a cutting torch.
3. List reasons for poor cuts.
4. List causes of a backfire.
5. Describe the results of a backfire.
6. Describe the results of a flashback.
7. List in the proper order the steps to follow in case of a flashback.
8. Name five factors that determine fusion weld quality.
9. List five properties of a good weld.
10. Name two factors that determine tip size selection in oxyacetylene fusion welding.
11. List two factors that determine the filler rod selection in oxyacetylene fusion welding.
12. State the purpose of the filler rod.
13. Identify three types of oxyacetylene fusion welding flames.
14. Discuss the advantages of braze welding.

15. Discuss the disadvantages of braze welding.

16. Discuss the characteristics of the elements found in the filler rods used in braze welding.

17. List two reasons for having a chemically clean metal surface in braze welding.

18. Name two methods for removing oxides from a clean metal surface.

19. Name purposes of flux.

20. Name the color of the base metal when the proper temperature is obtained in braze welding.

21. Describe the reaction of the molten bronze at different base metal temperatures.

22. Select from a list the proper tip size, acetylene pressure, and oxygen pressure for a given metal thickness.

23. State an acceptable lens shade number for oxyacetylene welding.

24. Demonstrate the ability to:

    a. Set up equipment for oxyacetylene cutting.

    b. Turn on, light, adjust to a neutral flame, and turn off the oxyacetylene cutting equipment.

    c. Make ninety degree cuts on mild steel and restart a cut.

    d. Cut a hole in mild steel.

    e. Lay beads on gauge metal without filler rod.

    f. Lay beads on gauge metal with filler rod.

    g. Weld butt joints with filler rod.

    h. Braze weld a square groove butt joint.

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Parts of a Torch Body and Cutting Attachment

      2. TM 2--Oxyacetylene Fusion Welding Flames

   D. Job sheets

      1. Job Sheet #1--Set Up Equipment for Oxyacetylene Cutting

2. Job Sheet #2--Turn On, Light, Adjust to a Neutral Flame, and Turn Off the Oxyacetylene Cutting Equipment
3. Job Sheet #3--Make Ninety Degree Cuts on Mild Steel and Restart a Cut
4. Job Sheet #4--Cut a Hole in Mild Steel
5. Job Sheet #5--Lay Beads on Gauge Metal Without Filler Rod
6. Job Sheet #6--Lay Beads on Gauge Metal With Filler Rod
7. Job Sheet #7--Weld Butt Joints With Filler Rod
8. Job Sheet #8--Braze Weld a Square Groove Butt Joint

E. Test

F. Answers to test

II. References:

A. *The Oxy-Acetylene Handbook.* New York, New York: Union Carbide Corporation/Linde Division, 1960.

B. *Welding Curriculum.* Stillwater, Oklahoma: State Department of Vocational and Technical Education, 1974.

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

INFORMATION SHEET

I. Terms and definitions

   A. Backfire--Momentary burning back of the flame into the tip

   B. Flame cutting--Process by which iron or steel is heated to a temperature where it can be rapidly oxidized by high purity oxygen flowing under pressure through a cutting torch

   (NOTE: As the metal is oxidized, the preheat flame maintains the temperature necessary to keep the oxidation process going in a narrow zone across the length of the base metal.)

   C. Slag box--Metal container with a layer of water or sand to catch hot slag

   D. Drag line--Refers to the situation in which the most distant portion of the cutting stream lags behind the stream nearest the cutting tip

   E. Kerf--Area where the metal was removed in the form of an oxide during the cutting process

   F. Oxide--Term usually applied to rust, corrosion, coating, film, or scale

   (NOTE: Oxygen combines with the metal causing oxides.)

   G. Oxidizing--Combining oxygen with another substance

   Example: A metal is oxidized when the metal is cut

   H. Fusion welding--Joining pieces of metal by heating the adjoining edges to the fusion or melting point and allowing them to flow or run together and then cool

   I. Penetration--Distance from the original surface of the base metal to the point at which fusion ceases

   J. Base metal--Metal being welded

   K. Inner cone--Inner white part of the neutral flame

   L. Tack weld--Short weld used for temporarily holding material in place

   M. Braze welding--Heating the base metal to a dull red color and depositing a bead over the seam (joint) with a bronze filler rod; the base metal is not melted

INFORMATION SHEET

N. Malleability--Property of metals which allows them to be bent or permanently distorted without rupture; opposite of brittleness

O. Ductile--Term describing metal which is capable of being drawn or stretched out

P. Tinning operation--Melting a small amount of bronze rod onto the surface and allowing it to spread along the entire seam (joint)

(NOTE: It is this flow of thin film of bronze which is known as tinning.)

Q. Flux--Chemical used to clean metals and to promote fusion during the welding process

(NOTE: Do not confuse this type of flux with silver brazing flux.)

R. Puddle--That portion of a weld that is molten at the place the heat is supplied

II. Parts of a cutting torch (Transparency 1)

A. Oxygen fitting

B. Acetylene fitting

C. Oxygen torch valve

D. Acetylene torch valve

E. Torch body

F. Oxygen cutting lever

G. Oxygen preheat valve

H. Tip nut

I. Slip-in tip

J. Preheat orifice--Heats metal to kindling point (cherry red) of approximately 1600°F

K. Cutting orifice--Removes oxidized metal

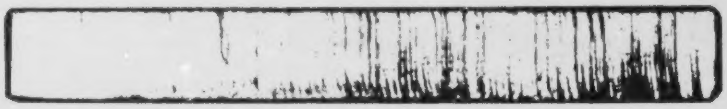
(NOTE: The selection of the correct tip for the job is determined by the thickness of metal, size of tip orifices, and the oxygen cutting pressures. See manufacturer's recommendations.)

INFORMATION SHEET

III. Reasons for poor cuts

(NOTE: This is a correctly made cut in 1 inch plate; the edge is square and the draglines are essentially vertical and not too pronounced.)

Example:



A. Preheat flames were too small causing cutting speed to be too slow

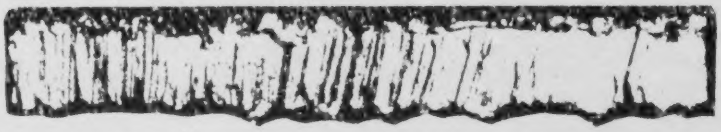
(NOTE: This results in bad gouging at the bottom.)

Example:

B. Preheat flames too long

(NOTE: The result is that the top surface has melted over, the cut edge is irregular, and there is an excessive amount of adhering slag.)

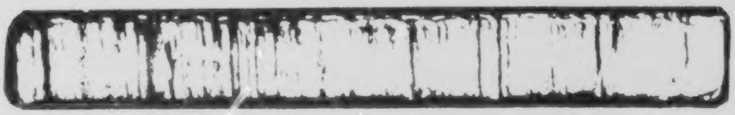
Example:



C. Oxygen pressure was too low

(NOTE: The result is that the top edge has melted over because of the too slow cutting speed.)

Example:

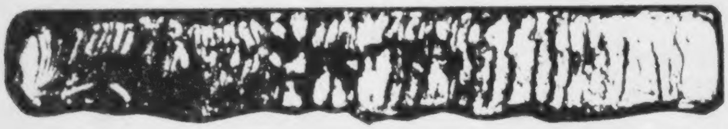


INFORMATION SHEET

D. Oxygen pressure too high and nozzle size too small

(NOTE: The result is that the entire control of the cut has been lost.)

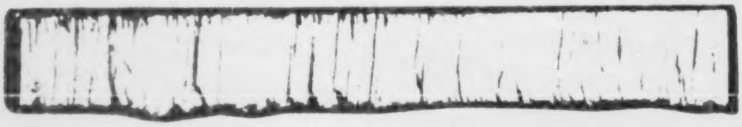
Example:



E. Cutting speed too slow

(NOTE: The result is that the irregularities of the draglines are emphasized.)

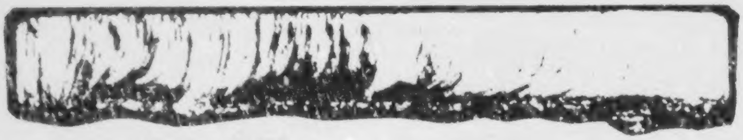
Example:



F. Cutting speed too high

(NOTE: The result is that there is a pronounced break to the dragline and the cut edge is irregular.)

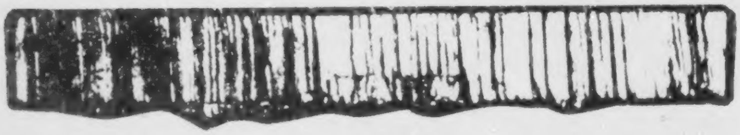
Example:



G. Blowpipe travel unsteady

(NOTE: The result is that the cut edge is wavy and irregular.)

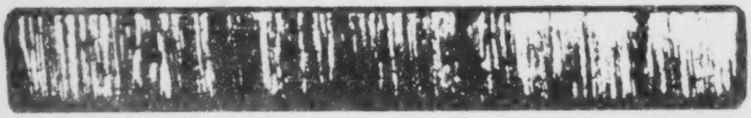
Example:



H. Cut lost and not carefully restarted

(NOTE: The result is that bad gouges were caused at the restarting point.)

Example:



INFORMATION SHEET

IV. Causes of backfire

   A. Insufficient acetylene or oxygen pressure

   B. Loose cutting tip

   C. Dirty tip

   D. Overheating of cutting tip

   E. Bad O-ring in torch body

   (NOTE: The above causes should be carefully checked to control backfire.)

V. Results of a backfire

   A. Flame burns momentarily back into tip

   B. A loud snap or pop results

      1. Flame may go out

      2. Flame may continue to burn in normal manner

VI. Results of a flashback

   A. Fire inside torch

   B. Disappearance of flame followed by

      1. Squealing or hissing noise inside torch

      2. Sparks coming from the torch

      3. Smoke coming from the torch

VII. Steps to follow in case of flashback

   A. Close oxygen preheat valve

   B. Close oxygen torch valve

   C. Close acetylene torch valve

   D. Release oxygen regulator screw

   E. Release acetylene regulator screw

   F. Examine acetylene unit

INFORMATION SHEET

G. Reset regulator pressures

H. Light torch

(NOTE: If heavy smoke comes out of the torch tip and the torch body becomes hot, the flashback has probably traveled past the mixing chamber into the hose. In this case, shut off the oxygen cylinder valve and the acetylene cylinder valve, then notify your instructor.)

VIII. Factors determining fusion weld quality

A. Proper flame adjustment

B. Angle of tip

C. Distance from work

D. Speed of travel

E. Movement of tip

IX. Properties of a good weld

A. Consistent width

B. Straightness

C. Slightly crowned

D. Fused into base metal

E. Clean appearance

X. Factors determining tip size selection

A. Metal thickness

B. Size of welding rod

(NOTE: Always use manufacturer's recommendations on tip size.)

XI. Factors determining filler rod selection

A. Rod with similar properties as base metal

B. Thickness of metal

(NOTE: A general rule is to use a rod with a diameter equal to the thickness of the base metal.)

INFORMATION SHEET

XII. Purpose of filler rod--To add strength to weld or joint

XIII. Oxyacetylene fusion welding flames (Transparency 2)

  A. Carburizing flame

    1. Contains excess of acetylene

       (NOTE: An acetylene feather is visible on the inner cone.)

    2. Recommended flame for cutting cast iron

    3. Introduces carbon into weld, causing hardening of the metal

       (NOTE: The resultant weld is weak.)

  B. Neutral flame

    1. Burns equal amounts of oxygen and acetylene

    2. Identified by clear, well defined white cone

    3. Temperature 5950°

  C. Oxidizing flame

    1. Burns excess of oxygen

    2. Identified by short white inner cone

    3. Oxidizes the metal causing it to harden and become brittle

    4. Not recommended for average cutting

    5. Is the hottest flame

    6. A slightly oxidizing flame is recommended for brazing

XIV. Advantages of braze welding

  A. Less possibility of destroying main characteristics of base metal

    1. Base metal does not have to be heated to a molten condition

      a. This increases the speed of joining metals

      b. Less gas is consumed for a given job

    2. In repairing malleable castings, there is less danger of its losing its ductile properties

INFORMATION SHEET

B. The low degree of heat minimizes expansion and contraction forces

C. Less need for extensive preheating

XV. Disadvantages of braze welding

A. Not recommended for parts which are to be raised to temperatures higher than the melting point of bronze, either in service or during heat treatment

B. Bronze will lose its strength at temperatures above 500°F

C. It cannot be used on metal where stress is a factor

D. Bronze may have corrosion resistant properties which differ from those of the base metal being used

XVI. Characteristics of the elements found in the filler rods used in braze welding

A. Consist of copper alloys containing about 60 percent copper and 40 percent zinc which:

1. Produce a high tensile strength

2. Increase ductility

B. Contain small quantities of tin, iron, manganese, and silicon which help to:

1. Deoxidize the weld metal

2. Decrease the tendency to fume

3. Increase the free flowing action of the molten metal

4. Increase the hardness of the deposited metal for greater wear resistance

XVII. Reasons for having a chemically clean metal surface in braze welding

A. To guarantee the molten bronze will stick to the base metal

B. To have a stronger bond on base metal

XVIII. Methods for removing oxides

A. Mechanical--Wire brush or grinder

INFORMATION SHEET

B. Chemical--Flux

(NOTE: Both methods should be employed to completely remove the oxides.)

XIX. Purposes of the flux

(NOTE: These purposes of flux pertain to fusion brazing and do not apply to the purposes of flux for silver brazing.)

A. Chemically cleans the base metal

B. Prevents oxidation of the filler metal

C. Floats and removes the oxides already present

D. Increases the flow of the filler metal

E. Increases the ability of the filler metal to adhere to the base metal

F. Brings the filler metal into immediate contact with the metals being joined

G. Permits the filler metal to penetrate the pores of the base metal

XX. Color of base metal when the proper temperature is obtained--Dull red

(NOTE: Base metal will begin to glow.)

XXI. Reaction of molten bronze at different base metal temperatures

A. Not hot enough--The molten bronze will not flow over the surface but will form into drops

B. Medium--The molten bronze will spread out evenly and flow over a considerable area

C. Too hot--The molten bronze will tend to boil and to form little balls

XXII. Tip sizes and gas pressures for different metal thicknesses (Table 1)

A. Tip size #000 to #12

B. Oxygen pressure 1/2 p.s.i. to 28 p.s.i.

C. Acetylene pressure 1/2 p.s.i. to 15 p.s.i.

INFORMATION SHEET

D. Metal thickness 1/32" to 4"

WELDING TIP SIZE AND APPLICATION

TIP SIZE	DRILL SIZE	LENGTH OF AVERAGE INNER FLAME CONE	OXYGEN PRESSURE P.S.I.		ACETYLENE PRESSURE P.S.I		METAL THICKNESS
			Min.	Max.	Min.	Max.	
000	75	7/32"	1/2	2	1/2	2	up to 1/32"
00	70	7/32"	1	2	1	2	1/64" - 3/64"
0	65	3/8"	1	3	1	3	1/32" - 5/64"
1	60	3/8"	1	4	1	4	3/64" - 3/32"
2	56	3/8"	2	5	2	5	1/16" - 1/8"
3	53	3/8"	3	7	3	7	1/8" - 3/16"
4	49	5/8"	4	10	4	10	3/16" - 1/4"
5	43	1"	5	12	5	15	1/4" - 1/2"
6	36	1-1/16"	6	14	6	15	1/2" - 3/4"
7	30	1-1/4"	7	16	7	15	3/4" -1- 1/4"
8	29	1-1/4"	9	19	8	15	1-1/4" - 2"
9	28	1-7/16"	10	20	9	15	2"-2- 1/2"
10	27	1-7/16"	11	22	10	15	2-1/2" - 3"
11	26	1-7/16"	13	24	11	15	3"-3 - 1/2"
12	25	1-1/2"	14	28	12	15	3-1/2" - 4"

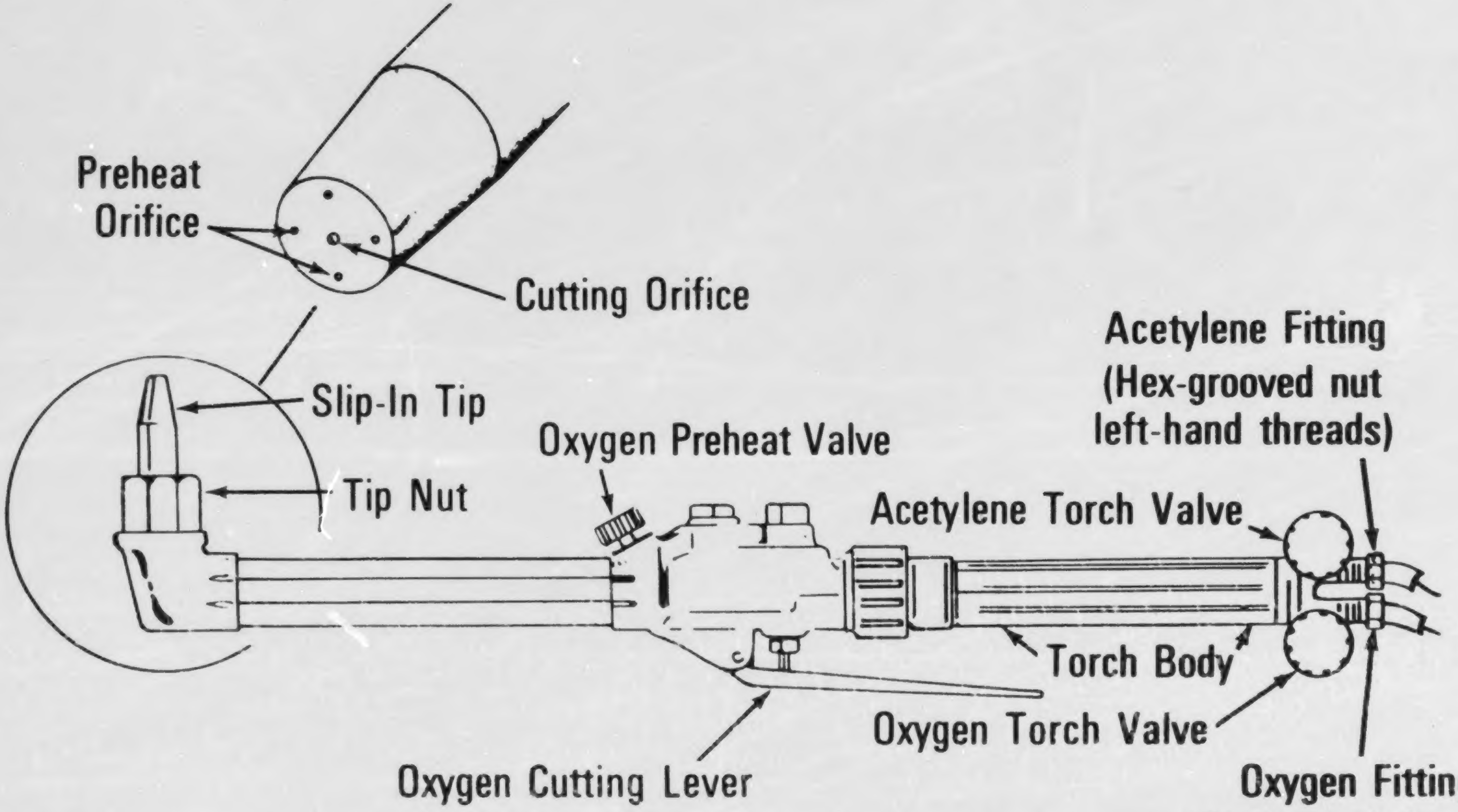
TABLE 1

XXIII. Safety lens

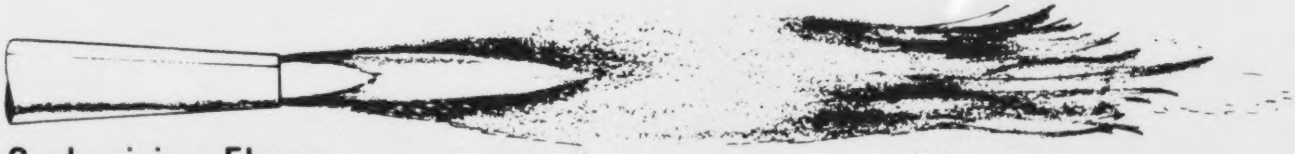
LENS SHADE SELECTOR

Types of operation	Shade number
Soldering	2
Torch brazing	3 or 4
Oxygen cutting	
0-1 inch	3 or 4
1-6 inches	3 or 5
6 inches and over	5 or 6
Gas welding	
0-1/8 inch	4 or 5
1/8-1/2 inch	5 or 6
1/2 inch and over	6 or 8

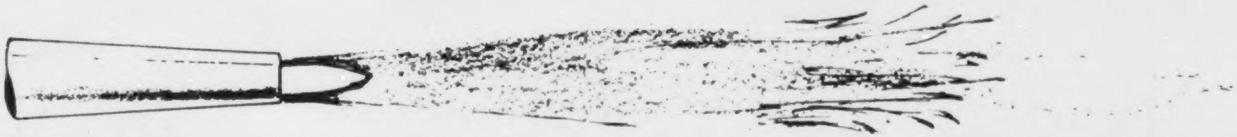
Parts of a Cutting Torch


Preheat Orifice
Cutting Orifice
Acetylene Fitting (Hex-grooved nut left-hand threads)
Slip-In Tip
Oxygen Preheat Valve
Tip Nut
Acetylene Torch Valve
Torch Body
Oxygen Torch Valve
Oxygen Cutting Lever
Oxygen Fitting (Right-hand threads)

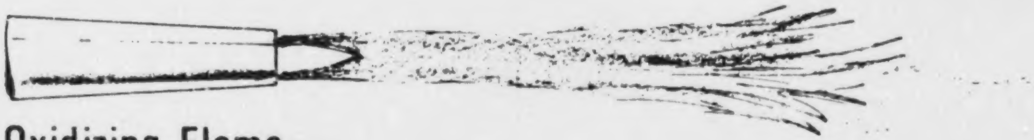
Oxyacetylene Fusion Welding Flames



Carburizing Flame



Neutral Flame



Oxidizing Flame

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

JOB SHEET #1--SET UP EQUIPMENT FOR OXYACETYLENE CUTTING

I. Tools and materials

  A. Oxygen cylinder

  B. Acetylene cylinder

  C. Oxygen regulator

  D. Acetylene regulator

  E. Hoses

  F. Wrench

  G. Cylinder holder

  H. Water container

  I. Soap

  J. Clean paintbrush

  K. Torch body with tips

II. Procedure

  A. Fasten cylinders in a vertical position

  B. Remove caps from cylinders

  C. Crack valves of each cylinder, then close valves

  D. Connect oxygen regulator to oxygen cylinder

    1. Turn adjusting screw on regulator counterclockwise until tension on spring is released

    2. Slowly turn cylinder valve wide open

  E. Connect acetylene regulator to acetylene cylinder

    1. Turn adjusting screw on regulator counterclockwise until tension on spring is released

    2. Open cylinder valve 1/2 to 3/4 of a turn (never more than 1 1/2 turns)

JOB SHEET #1

F. Connect acetylene hose to acetylene regulator and purge hose

G. Connect oxygen hose to oxygen regulator and purge hose

H. Connect torch body to oxygen and acetylene hose and close both valves on torch body

I. Attach cutting attachment to torch body

(NOTE: The tip size is determined by the thickness of metal to be cut and the manufacturer's recommendations.)

J. Close oxygen preheat valve on cutting attachment

K. Turn adjusting screw on oxygen regulator clockwise until working pressure is reached

L. Turn adjusting screw on acetylene regulator clockwise until correct working pressure is reached

M. Test all connections for leaks with soap suds and water

(NOTE: Apply soap suds with a clean paintbrush.)

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

JOB SHEET #2--TURN ON, LIGHT, ADJUST TO A NEUTRAL FLAME, AND TURN OFF THE OXYACETYLENE CUTTING EQUIPMENT

I. Tools and materials

  A. Oxygen cylinder

  B. Acetylene cylinder

  C. Hoses

  D. Oxygen and acetylene regulators

  E. Torch body

  F. Cutting attachment with slip-in tip

  G. Cylinder holder and hose rack

  H. Striker

  I. Wrench

  J. Gloves

  K. Colored safety glasses

  L. Coveralls or protective clothing

II. Procedure

  A. Turn on, light, and adjust the cutting torch to a neutral flame

    1. Check all cylinder, regulator, and torch valves to make sure they are off

    2. Open acetylene cylinder valve 1/2 to 3/4 of a turn (never more than 1 1/2 turns)

    3. Open acetylene valve on torch one turn

    4. Turn adjusting screw on acetylene regulator clockwise until desired pressure is reached

    (NOTE: Oxygen and acetylene pressures and size of tip depend upon the thickness of the metal to be cut. Use pressures and tip sizes recommended by the manufacturers.)

JOB SHEET #2

5. Close acetylene valve on torch
6. Open oxygen cylinder valve all the way
7. Open oxygen torch valve all the way
8. Open oxygen preheat valve on cutting attachment one turn
9. Turn adjusting screw on oxygen regulator clockwise until desired pressure is reached
10. Close oxygen preheat valve on cutting attachment
11. Open acetylene valve on torch 1/4 turn
12. Light the torch with striker and adjust until smoke on flame clears
13. Open oxygen preheat valve slowly and adjust to a neutral flame
14. Depress the oxygen cutting lever and check to see that a neutral flame is present

    (NOTE: If necessary, adjust the oxygen preheat valve with the oxygen cutting lever depressed until a neutral flame is secured.)

B. Turn off the flame and oxyacetylene unit

1. Close acetylene valve on torch
2. Close oxygen preheat valve
3. Close acetylene cylinder valve
4. Close oxygen cylinder valve
5. Open acetylene valve on torch

    (NOTE: When gauges reach 0, close torch valve and release adjusting screw on acetylene regulator by turning counterclockwise.)

6. Open oxygen preheat valve on torch

    (NOTE: When gauges reach 0, close oxygen preheat valve and release adjusting screw on oxygen regulator by turning counterclockwise.)

7. Close oxygen valve on torch
8. Place torch and hose on hanger or brackets provided

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

JOB SHEET #3--MAKE NINETY DEGREE CUTS ON MILD STEEL AND RESTART A CUT

I. Tools and materials

  A. Cutting outfit with tip assembly

  B. Mild steel plate 1/4" to 1/2" thick, 4" wide or wider, 8" long or longer

  C. Soapstone with a sharp point or edge

  D. Straight edge

  E. Gloves

  F. Colored safety glasses

  G. Pliers

  H. Protective clothing

  I. Striker

  J. Welding or cutting table

  K. Slag box

  L. Can of water

  M. Cutting tip

II. Procedure

  A. Make ninety degree cut

    1. Mark four parallel lines 2" apart on plate to be cut

    2. Adjust oxygen regulator

    3. Adjust acetylene regulator

    4. Place plate to be cut over slag box

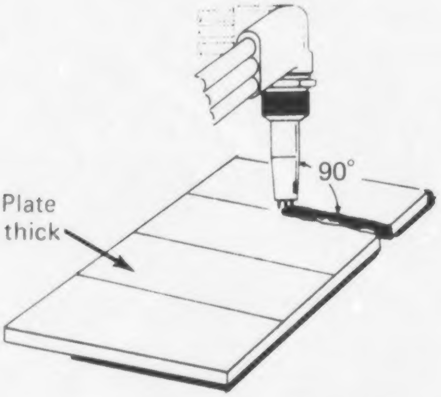
    5. Light torch

    6. Adjust to neutral flame

JOB SHEET #3

7. Assume comfortable position
8. Place hoses behind operator
9. Maneuver torch with both hands
10. Hold preheat flame with tip of inner cone 1/16" to 1/8" above top of plate at right edge until red spot appears
11. Depress the oxygen cutting lever, and move from right to left across the plate (for left-handed operators, go from left to right) (Figure 1)

FIGURE 1



12. Hold the tip at right angles to work while cutting with inner cone being 1/16" to 1/8" above work
13. Make 90° cuts until you have developed the proper procedure
14. Cool metal by placing in can of water with the aid of pliers
15. Have instructor inspect

B. Restart cut

1. Release the oxygen cutting lever
2. Preheat only the edge where cutting action was stopped

C. Slowly depress oxygen cutting lever and continue cut

OXYACETYLENE CUTTING WELDING, AND BRAZING
UNIT V

JOB SHEET #4--CUT A HOLE IN MILD STEEL

I. Tools and materials

- A. Cutting outfit with tip
- B. Mild steel plates
- C. Soapstone with a sharp point or edge
- D. Straight edge
- E. Gloves
- F. Colored safety glasses
- G. Pliers
- H. Protective clothing
- I. Striker
- J. Welding or cutting table
- K. Slag box
- L. Can of water

II. Procedure

- A. Draw two circles on metal
    1. Draw one circle 1" in diameter, 1" from edge
    2. Draw the other circle 1/2" in diameter, 1" from edge
- B. Adjust oxygen regulator
- C. Adjust acetylene regulator
- D. Place metal to be cut over slag box
- E. Light torch

JOB SHEET #4

F. Adjust to neutral flame

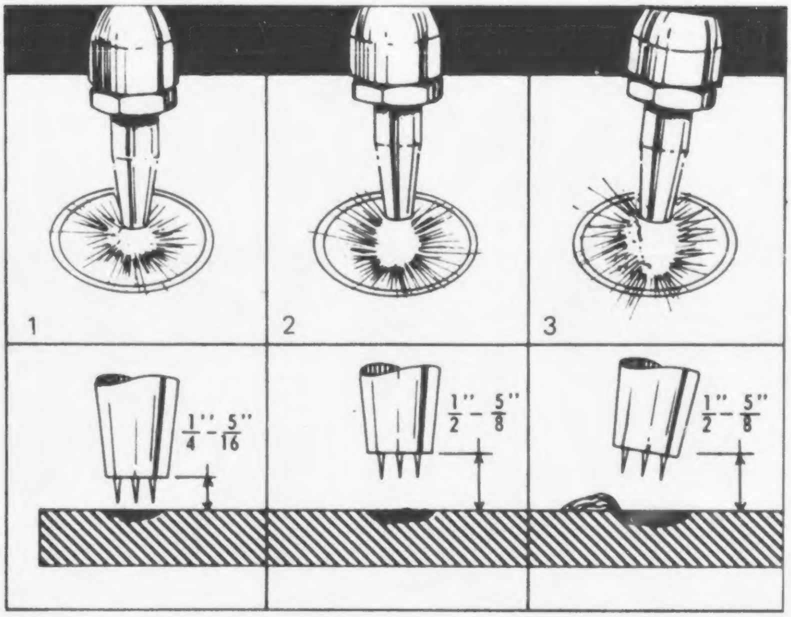
G. Assume comfortable position

H. Place hoses behind operator

I. Maneuver torch with both hands

J. Hold tip of inner cone 1/16" to 1/8" above point to be cut until metal turns bright red (Figure 1)

FIGURE 1



1. Tilt torch 15° from vertical position

   (NOTE: This will allow molten metal to be blown away from operator.)

2. Depress oxygen cutting lever slowly moving torch backwards (to the operator's right if right handed) until cut pierces plate

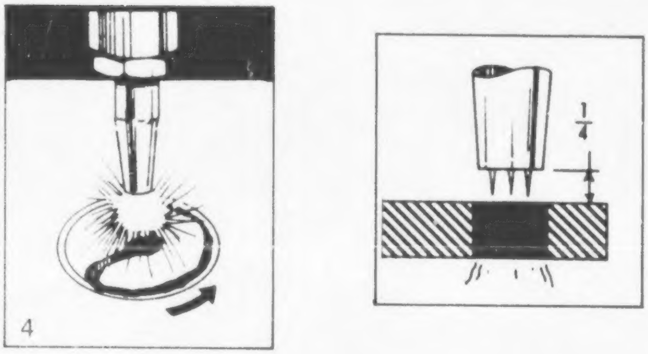
JOB SHEET #4

K. Return cutting torch to vertical position

  1. Raise cutting tip until tip of inner cone is from 1/4" to 1/2" above the plate

  2. Make cut (Figure 2)

FIGURE 2



L. Cut just inside soapstone mark until circular cut is completed

M. Repeat steps K and L until all holes are cut

N. Turn off oxyacetylene rig

O. Cool metal by placing in can of water with the aid of pliers

P. Have instructor inspect

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

JOB SHEET #5--LAY BEADS ON GAUGE METAL WITHOUT FILLER ROD

I. Tools and materials

   A. Oxyacetylene welding unit

   B. Welding tip #8

   C. Gloves

   D. Colored safety glasses

   E. Pliers

   F. Wire brush

   G. Striker

   H. Fire brick

   I. One piece of 16 gauge mild steel, 1 1/4" x 6"

II. Procedure

   A. Prepare metal for welding

   B. Place metal in welding position

   C. Turn on oxyacetylene unit

   D. Set working pressure

   E. Light torch and adjust to a neutral flame

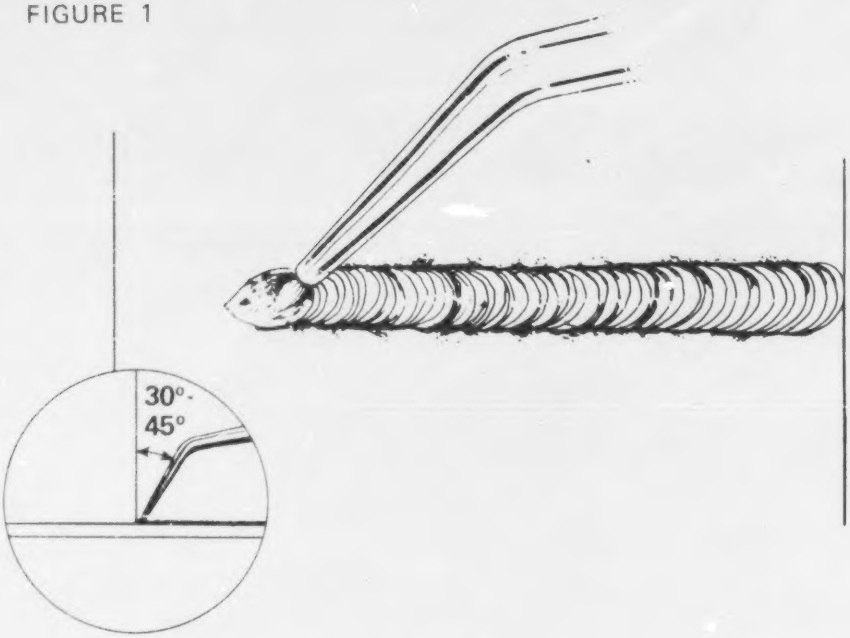
   F. Place inner cone about 1/16" to 1/8" from metal

   G. Do not begin travel until you have established a molten puddle

JOB SHEET #5

H. Hold torch 30° to 45° from center in direction of travel (Figure 1)

FIGURE 1



I. Slowly move the torch forward allowing the metal to melt

J. Repeat process until instructor gives permission to go on to next job

(NOTE: Always turn off oxyacetylene rig when not using it.)

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

JOB SHEET #6--LAY BEADS ON GAUGE METAL WITH FILLER ROD

I. Tools and materials

  A. Oxyacetylene welding unit

  B. Welding tip (according to manufacturer's recommendations)

  C. Gloves

  D. Colored safety glasses

  E. Pliers

  F. Wire brush

  G. Striker

  H. Fire brick

  I. One piece of mild steel strip, 16 gauge 1 1/4" by 6"

  J. Filler rod mild steel (according to manufacturer's recommendations)

II. Procedure

  A. Prepare metal for welding

  B. Place metal in welding position

  C. Turn on oxyacetylene unit

  D. Set working pressure

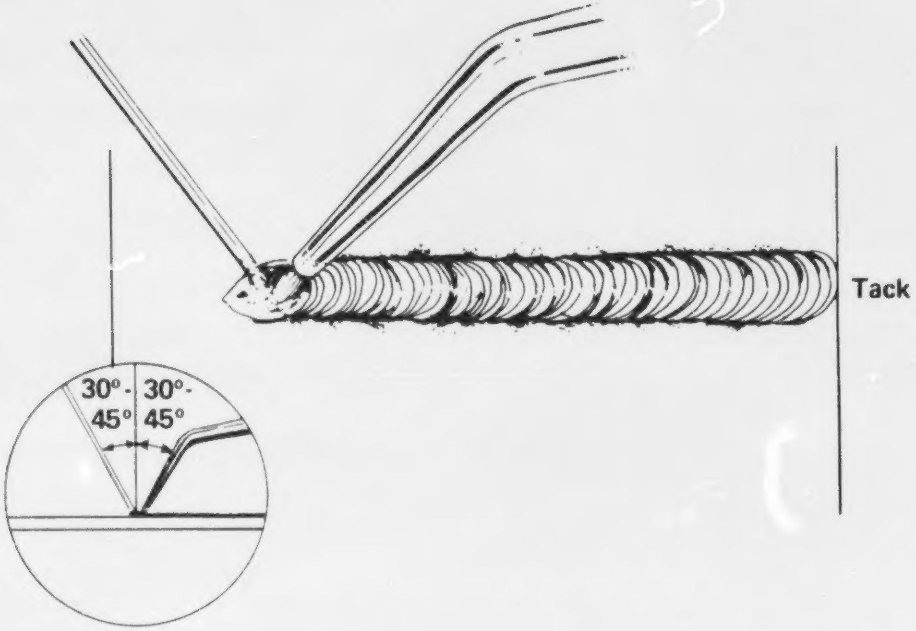
  E. Light torch and adjust to a neutral flame

  F. Hold torch 30° to 45° from center

JOB SHEET #6

G. Place inner cone about 1/16" to 1/8" from surface of puddle (Figure 1)

FIGURE 1



H. Do not begin travel until you have established a molten puddle

I. Add filler rod to front edge of puddle in front of torch

J. Move puddle forward with torch and allow puddle to form in base metal

K. Add rod and withdraw rod to front edge of puddle as you move puddle forward

L. Keep puddle the same size and shape the entire length of the bead

M. Turn off oxyacetylene rig

N. Have instructor inspect

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

JOB SHEET #7--WELD BUTT JOINTS WITH FILLER ROD

I. Tools and materials

  A. Oxyacetylene welding unit

  B. Welding tip (according to manufacturer's recommendations)

  C. Gloves

  D. Colored safety glasses

  E. Pliers

  F. Wire brush

  G. Striker

  H. Fire brick

  I. Two pieces of mild steel strips, 16 gauge 1 1/4" by 6"

  J. Filler rod mild steel (according to manufacturer's recommendations)

II. Procedure

  A. Prepare metal for welding

  B. Place metal in welding position

  C. Turn on oxyacetylene unit

  D. Set working pressure

  E. Light torch and adjust to a neutral flame

  F. Tack weld metal together at both ends of joint

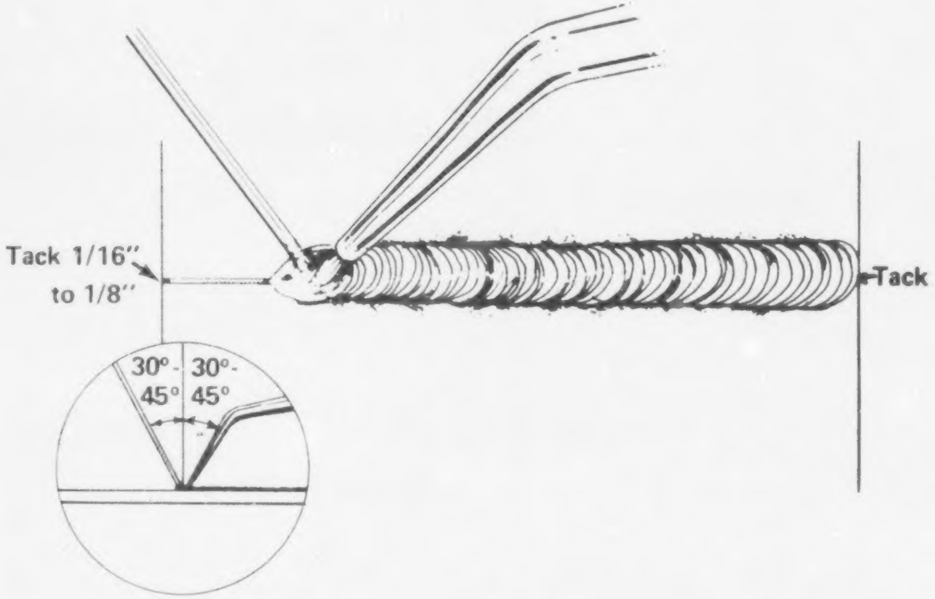
  G. Hold torch 30° to 45° from center

  H. Do not begin travel until you have established a molten puddle

JOB SHEET #7

I. Place inner cone about 1/16" to 1/8" from surface of puddle (Figure 1)

FIGURE 1



J. Add filler rod to front edge of puddle in front of torch

K. Move puddle forward with torch and allow puddle to form in base metal

L. Add rod and withdraw rod to front edge of puddle as you move puddle forward

M. Keep puddle the same size, shape, and centered the entire length of the bead

N. Turn off oxyacetylene rig

O. Show bead to instructor when completed

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

JOB SHEET #8--BRAZE WELD A SQUARE GROOVE BUTT JOINT

I. Tools and materials

  A. Oxyacetylene welding unit

  B. Gloves

  C. Colored safety glasses

  D. Goggles

  E. Welding tip (according to manufacturer's recommendations)

  F. Wire brush

  G. Striker

  H. Fire brick

  I. Two pieces of clean mild steel strips, 1/8" thick, 1 1/4" by 6"

  J. Bronze filler rod (use according to manufacturer's recommendations)

  K. Welding flux

II. Procedure

  A. Prepare metal for brazing--clean

  B. Place metal in brazing position--1/16" to 1/8" apart

  C. Turn on oxyacetylene unit

  D. Adjust proper working pressure of oxygen and acetylene

  E. Place metal on fire brick

  (NOTE: Do not lay metal flat on brick. Arrange metal so a small space will be between the base metal and the fire brick.)

  F. Light and adjust torch to a neutral or slightly oxidized flame

  G. Preheat the end of the brazing rod and dip in the flux or use fluxed rod

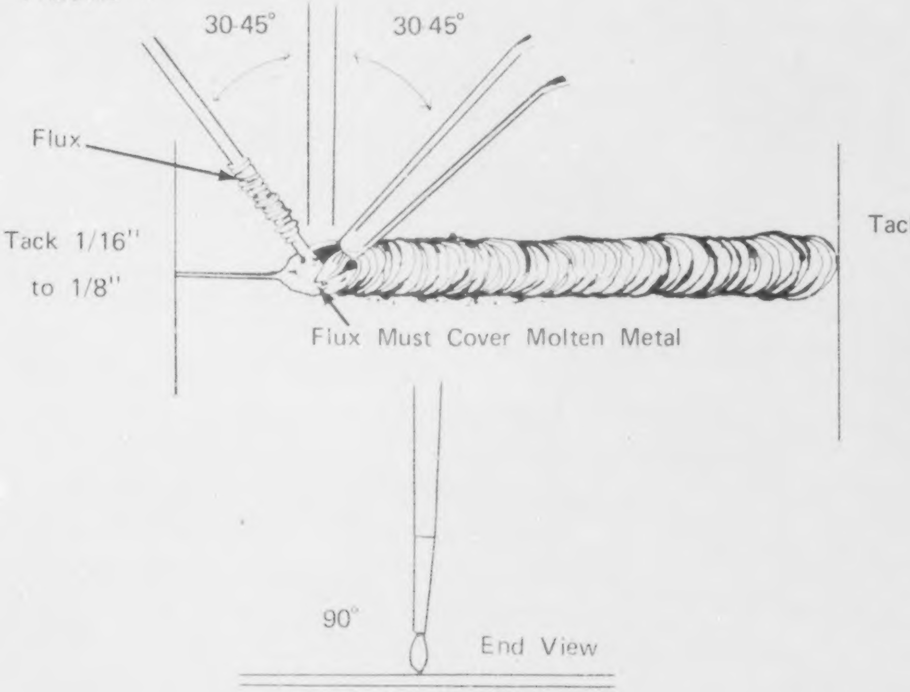
JOB SHEET #8

H. Tack metal in place using braze filler metal

I. Heat the surface of the weld area slightly

J. Hold torch 30° to 45° from vertical; hold filler rod at the same angle in opposite direction (Figure 1)

FIGURE 1



K. Melt a small amount of bronze rod onto the surface and allow it to spread along the entire seam when a dull cherry-red color occurs

L. When the base metal is tinned sufficiently, start depositing the proper size bead

M. Watch for base metal color

(NOTE: When metal is not hot enough, the bronze will form into drops; when metal is too hot, bronze tends to boil. This is indicated by excessive white smoke.)

N. Turn off oxyacetylene rig

O. Inspect weld then check with instructor

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

TEST

1. Match the terms on the right to the correct definitions.

______a. Chemical used to clean metals and to promote fusion during the welding process

______b. Melting a small amount of bronze rod onto the surface and allowing it to spread along the entire seam (joint)

______c. Joining pieces of metal by heating the adjoining edges to the fusion or melting point and allowing them to flow or run together and then cool

______d. Momentary burning back of the flame into the tip

______e. Process by which iron or steel is heated to a temperature where it can be rapidly oxidized by high purity oxygen flowing under pressure through a cutting torch

______f. Inner white part of the neutral flame

______g. Short weld used for temporarily holding material in place

______h. Metal container with a layer of water or sand to catch hot slag

______i. Area where the metal was removed in the form of an oxide during the cutting process

______j. Term usually applied to rust, corrosion, coating, film, or scale

______k. Heating the base metal to a dull red color and depositing a bead over the seam (joint) with a bronze filler rod; the base metal is not melted

______l. That portion of a weld that is molten at the place the heat is supplied

1. Backfire
2. Flame cutting
3. Oxide
4. Base metal
5. Malleability
6. Ductile
7. Flux
8. Kerf
9. Slag box
10. Oxidizing
11. Tack weld
12. Tinning operation
13. Penetration
14. Drag line
15. Fusion welding
16. Braze welding
17. Inner cone
18. Puddle

______m. Combining oxygen with another substance

______n. Refers to the situation in which the most distant portion of the cutting stream lags behind the stream nearest the cutting tip

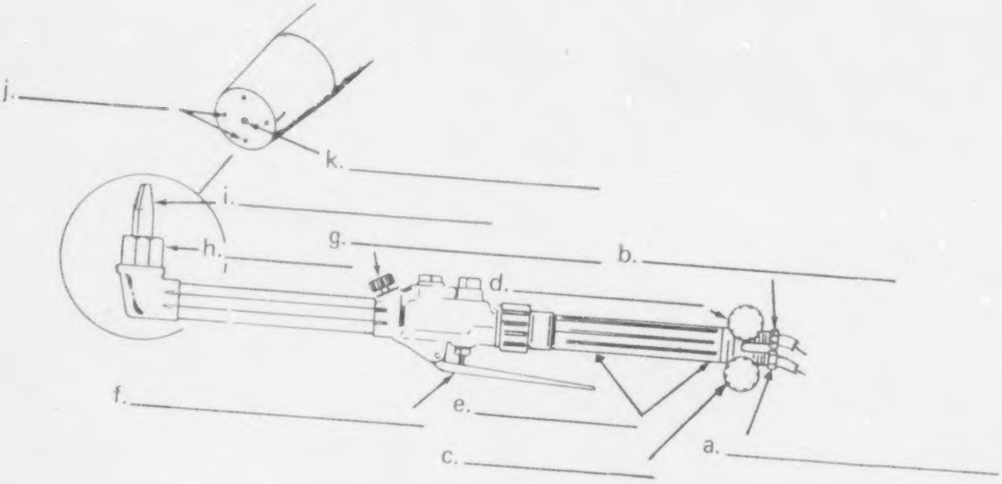
______o. Property of metals which allows them to be bent or permanently distorted without rupture; opposite of brittleness

______p. Term describing metal which is capable of being drawn or stretched out

______q. Distance from the original surface of the base metal to the point at which fusion ceases

______r. Metal being welded

2. Identify the parts of the cutting torch.



3. List five reasons for poor cuts.

a.

b.

c.

d.

e.

4. List four causes of a backfire.

   a.

   b.

   c.

   d.

5. Describe the results of a backfire.

6. Describe the results of a flashback.

7. List in the proper order the steps to follow in case of a flashback.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

8. Name five factors that determine fusion weld quality.

   a.

   b.

   c.

   d.

   e.

9. List five properties of a good weld.

   a.

   b.

   c.

   d.

   e.

10. Name two factors that determine tip size selection in oxyacetylene fusion welding.

   a.

   b.

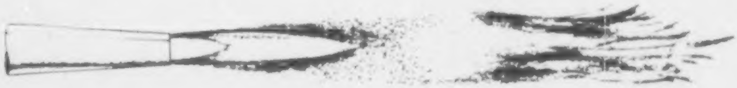
11. List two factors that determine the filler rod selection in oxyacetylene fusion welding.

   a.

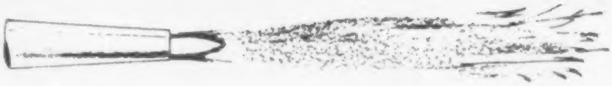
   b.

12. State the purpose of the filler rod.

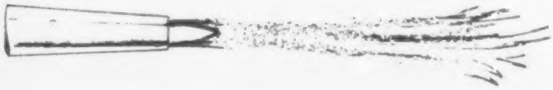
13. Identify the types of oxyacetylene fusion welding flames.



   a. ____________________



b. ______________________________



c. ______________________________

14. Discuss the advantages of braze welding.

15. Discuss the disadvantages of braze welding.

16. Discuss the characteristics of the elements found in the filler rods used in braze welding.

17. List two reasons for having a clean metal surface in braze welding.

    a.

    b.

18. Name two methods for removing oxides from a clean metal surface.

    a.

    b.

19. Name five purposes of flux.

    a.

    b.

    c.

    d.

    e.

20. Name the color of the base metal when the proper temperature is obtained in braze welding.

21. Describe the reaction of the molten bronze at different base metal temperatures.

    a. Not hot enough--

    b. Medium--

    c. Too hot--

22. Select the proper tip size, oxygen pressure, and acetylene pressure for weld 3/8" steel.

Tip Size	Oxygen Pressure	Acetylene Pressure	Metal Thickness
000	1/2-2	1/2-2	Up to 1/32"
00	1-2	1-2	1/64" to 3/64"
0	1-3	1-3	1/32" to 5/65"
1	1-4	1-4	3/64" to 3/32"
2	2-5	2-5	1/16" to 1/8"
3	3-7	3-7	1/8" to 3/16"
4	4-10	4-10	3/16" to 1/4"
5	5-12	5-15	1/4" to 1/2"
6	6-14	6-15	1/2" to 3/4"
7	7-16	7-15	3/4" to 1 1/4"
8	9-19	8-15	1 1/4" to 2"
9	10-20	9-15	2" to 2 1/2"
10	11-22	10-15	2 1/2" to 3"
11	13-24	11-15	3" to 3 1/2"
12	14-28	12-15	3 1/2" to 4"

23. State an acceptable lens shade number for oxyacetylene welding.

24. Demonstrate the ability to:

    a. Set up equipment for oxyacetylene cutting.

    b. Turn on, light, adjust to a neutral flame, and turn off the oxyacetylene cutting equipment.

    c. Make ninety degree cuts on mild steel and restart a cut.

    d. Cut a hole in mild steel.

e. Lay beads on gauge metal without filler rod.

f. Lay beads on gauge metal with filler rod.

g. Weld butt joints with filler rod.

h. Braze weld a square groove butt joint.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

OXYACETYLENE CUTTING, WELDING, AND BRAZING
UNIT V

ANSWERS TO TEST

1. a. 7
   b. 12
   c. 15
   d. 1
   e. 2
   f. 17
   g. 11
   h. 9
   i. 8
   j. 3
   k. 16
   l. 18
   m. 10
   n. 14
   o. 5
   p. 6
   q. 13
   r. 4

2. a. Oxygen fitting
   b. Acetylene fitting
   c. Oxygen torch valve
   d. Acetylene torch valve
   e. Torch body
   f. Oxygen cutting lever
   g. Oxygen preheat valve
   h. Tip nut
   i. Slip-in tip
   j. Preheat orifice
   k. Cutting orifice

3. Any five of the following:
   a. Preheat flames too small causing cutting speed to be too slow
   b. Preheat flames too long
   c. Oxygen pressure too low
   d. Oxygen pressure too high and nozzle size too small
   e. Cutting speed too slow

- f. Cutting speed too high
- g. Blowpipe travel unsteady
- h. Cut lost and not carefully restarted

4. Any four of the following:
    - a. Insufficient acetylene or oxygen pressure
    - b. Loose cutting tip
    - c. Dirty tip
    - d. Overheating of cutting tip
    - e. Bad O-ring in torch body
5. Description should include:
    - a. Flame burns momentarily back into tip
    - b. A loud snap or pop results
        - 1) Flame may go out
        - 2) Flame may continue to burn in normal manner
6. Description should include:
    - a. Fire inside torch
    - b. Disappearance of flame followed by
        - 1) Squealing or hissing noise inside torch
        - 2) Sparks coming from the torch
        - 3) Smoke coming from the torch
7. a. Close oxygen preheat valve
    - b. Close oxygen torch valve
    - c. Close acetylene torch valve
    - d. Release oxygen regulator screw
    - e. Release acetylene regulator screw
    - f. Examine acetylene unit

g. Reset regulator pressures

h. Light torch

8. a. Proper flame adjustment
   b. Angle of tip
   c. Distance from work
   d. Speed of travel
   e. Movement of tip

9. a. Consistent width
   b. Straightness
   c. Slightly crowned
   d. Fused into base metal
   e. Clean appearance

10. a. Metal thickness
    b. Size of welding rod

11. a. Rod with similar properties as base metal
    b. Thickness of metal

12. To add strength to weld or joint

13. a. Carburizing flame
    b. Neutral flame
    c. Oxidizing flame

14. Discussion should include:
    a. Less possibility of destroying the main characteristics of the base metal
       1) Base metal does not have to be heated to a molten position
          a) This increases the speed of joining metals
          b) Less gas is consumed for a given job
       2) In repairing malleable castings, there is less danger of its losing its ductile properties

b. The low degree of heat minimizes expansion and contraction forces

c. Less need for extensive preheating

15. Discussion should include:

    a. Not recommended for parts which are to be raised to temperatures higher than the melting point of bronze, either in service or during heat treatment

    b. Bronze will lose its strength at temperatures above 500°F

    c. It cannot be used on metal where stress is a factor

    d. Bronze may have corrosion resistant properties which differ from those of the base metal being used

16. Discussion should include:

    a. Consist of copper alloys containing about 60 percent copper and 40 percent zinc which:

        1) Produce a high tensile strength

        2) Increase ductility

    b. Contain small quantities of tin, iron, manganese, and silicon which help to:

        1) Deoxidize the weld metal

        2) Decrease the tendency to fume

        3) Increase the free flowing action of the molten metal

        4) Increase the hardness of the deposited metal for greater wear resistance

17. a. To guarantee the molten bronze will stick to the base metal

    b. To have a stronger bond on base metal

18. a. Mechanical--Wire brush or grinder

    b. Chemical--Flux

19. Any five of the following:

    a. Chemically cleans the base metal

    b. Prevents oxidation of the filler metal

    c. Floats and removes the oxides already present

   d. Increases the flow of the filler metal

   e. Increases the ability of the filler metal to adhere to the base metal

   f. Brings the filler metal into immediate contact with the metals being joined

   g. Permits the filler metal to penetrate the pores of the base metal

20. Dull red

21. a. Not hot enough--The molten bronze will not flow over the surface but will form into drops

    b. Medium--The molten bronze will spread out evenly and flow over a considerable area

    c. Too hot--The molten bronze will tend to boil and to form little balls

22. 5, 5-12, 5-15

23. 4 or 5

24. Performance skills evaluated to the satisfaction of the instructor

ELECTRIC WELDING
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to name the types of arc welding machines and electrodes. The student should be able to do a vertical butt and "T" or fillet weld with the electric welder. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with electric welding to the correct definitions.
2. Name four types of arc welding machines.
3. Distinguish between straight and reverse polarity.
4. Name the two types of operating adjustments found on arc welding machines.
5. Discuss how to test for polarity.
6. Name types of electrodes.
7. Name common sizes of electrodes.
8. Select the statement which determines electrode size.
9. Select the purposes of flux coating on electrodes.
10. Identify the numbers in the AWS electrode code classification.
11. Name factors to be considered when selecting an electrode for a specific job application.
12. Select reasons for poor welds.
13. Identify the parts of the welding process.
14. Name two methods of striking an arc.
15. State the correct range of lens shade number for electric welding.
16. Select reasons for removing slag from weld.

17. Name three reasons for fusing one bead in with another.

18. Name four factors that determine weld quality.

19. Identify properly and improperly formed beads by telling what caused each one.

20. Demonstrate the ability to:

    a. Start, stop and restart a bead.

    b. Make a pad in the flat position.

    c. Make a square groove butt weld.

    d. Make a multiple pass T-joint fillet weld.

ELECTRIC WELDING
UNIT VI

SUGGESTED ACTIVITIES

I. Instructor:
   A. Provide student with objective sheet.
   B. Provide student with information and job sheets.
   C. Make transparencies.
   D. Discuss unit and specific objectives.
   E. Discuss information sheet.
   F. Demonstrate and discuss the procedures outlined in the job sheets.
   G. Give test.

II. Student:
   A. Read objective sheet.
   B. Study information sheet.
   C. Complete job sheets.
   D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:
   A. Objective sheet
   B. Information sheet
   C. Transparency masters
      1. TM 1--Welding Circuit
      2. TM 2--Standardized AWS Classification
      3. TM 3--Direction of Travel
      4. TM 4--Improperly Formed Beads

D. Job sheets

1. Job Sheet #1--Start, Stop, and Restart a Bead
2. Job Sheet #2--Make a Pad in the Flat Position
3. Job Sheet #3--Make a Square Groove Butt Weld
4. Job Sheet #4--Make a Multiple Pass T-Joint Fillet Weld

E. Test

F. Answers to test

II. References:

A. Sosnin, H. A. *Arc Welding Instructions for the Beginner.* Cleveland, Ohio: The James F. Lincoln Arc Welding Foundation, 1973.

B. *Welding Curriculum.* Stillwater, Oklahoma: State Department of Vocational and Technical Education, 1974.

ELECTRIC WELDING
UNIT VI

INFORMATION SHEET

I. Terms and definitions

A. Shielded metal arc welding--Arc welding process wherein metals are united by heating with an electric arc between a coated metal electrode and the metal

B. Base metal--Metal to be welded or cut

C. Arc length--Distance from the end of the electrode to the point where the arc makes contact with work surface

D. Crater--Depression at the termination of a weld

E. Face of weld--Exposed surface of a weld, made by an arc or gas welding process, on the side from which welding was done

F. Flux--Fusible material or gas used to dissolve and/or prevent the formation of oxides, nitrides, or other undesirable inclusions formed in welding

G. Low carbon steel--Steel containing .20% or less carbon

H. Pass--Single longitudinal progression of a welding operation along a joint or weld deposit

I. Porosity--Gas pockets or voids in metal

J. Spatter--Metal particles given off during welding which do not form a part of the weld

K. Tack weld--Weld made to hold parts in proper alignment until the final welds are made

(NOTE: This type of welding is for assembly purposes only.)

L. Puddle--That portion of a weld that is molten at the place the heat is supplied

M. Undercut--Groove melted into the base metal adjacent to the toe of the weld and left unfilled by weld metal

N. Weaving--Technique of depositing weld metal in which the electrode is oscillated

O. Weld metal--That portion of a weld which has been melted during welding

INFORMATION SHEET

P. Whipping--Term applied to an inward and upward movement of the electrode which is employed in vertical welding to avoid undercut

Q. AWS--American Welding Society

R. Disposition rate--Amount of filler metal deposited in any welding process; rated in pounds per hour

II. Types of arc welding machines

A. AC (alternating current) transformer welder--Current alternating direction 120 times per second

B. AC-DC transformer rectifier--Provides either alternating current or direct current

C. Motor generator--Produces DC current

D. Engine generator--Produces DC current

III. Types of polarity (Transparency 1)

A. Reverse--Current flows from base metal to electrode

B. Straight--Current flows from electrode to base metal

(NOTE: Welding leads must connect to correct terminals if machine has a polarity switch. Otherwise a change in polarity is made by reversing leads on the terminals.)

IV. Types of operating machine adjustments

A. Current (amperage) settings

(NOTE: Increasing amps produces more heat and decreasing amps produces less heat.)

B. Polarity

V. How to test for polarity

A. Weld a bead using E-6010 reverse polarity electrode

(NOTE: If there is excessive amount of weld spatter and arc is very erratic, machine is set on straight polarity, electrode lead negative, work lead (ground) positive. Reverse polarity should have electrode lead positive, work lead (ground) negative. The same practice would apply if machine is set on AC.)

INFORMATION SHEET

B. Strike arc with carbon electrode

(NOTE: If arc is smooth and quiet, it is set on straight polarity. If carbon becomes extremely hot and pieces break off and black smudges appear on work piece, it is set on reverse polarity.)

VI. Types of electrodes

A. Mild steel

B. Low hydrogen-low alloy

C. Nonferrous

D. Hard surfacing

E. Cast iron

F. Stainless steel

Example:

WELDING CHARACTERISTICS AND OPERATING DATA OF MILD STEEL ELECTRODES

	Coating Color	Position of Welding	Type of Current* Used	Penetration	Rate of Deposition	Appearance of Bead	Minimum Tensile Strength	3/32" Size	1/8" Size	5/32" Size	3/16" Size
E6010	White	All Positions	DC, Reverse (+)	Deep	Av. Rate	Rippled and Flat	62,000psi		75-130	90-175	140-225
E6011	White	All Positions	AC DC, Reverse (+)	Deep	Av. Rate	Rippled and Flat	62,000psi		75-120 70-110	90-160 80-145	120-200 110-180
E6012	Tan	All Positions	DC, Str AC (-)	Medium	Good Rate	Smooth and Convex	67,000psi	55-80 60-90	80-135 90-150	110-180 120-200	155-250 170-275
E6013	Dark Tan	All Positions	AC DC, Str (-) or Reverse	Mild	Good Rate	Smooth, Flat and Convex	67,000psi	65-100 60-90	90-140 80-125	140-200 125-180	200-260 180-235
E7014	Gray dr.	All Positions	AC DC, Str (-) or Reverse	Medium	High Rate	Smooth, Flat and Convex	70,000		110-160 100-145	150-225 1350200	200-280 180-250
E7016		All Positions	AC DC, Reverse (+)	Mild to Medium	Good Rate	Smooth and Convex	70,000	70-100	80-130	120-170	170-250
E7024	Dark Gray	Flat Hor Fillets	AC, DC Straight or Reverse	Mild	Very High Rate	Smooth and Slightly Cvx	72,000	65-120 60-110	115-175 100-160	180-240 160-215	240-300 220-280
E6027	Red Brown *	Flat Hor. Fillets	Flat-DC AC Hor Fillet DC Str AC	Medium	Very High Rate	Flat to Concave	62,000psi			190-240 175-215	250-300 230-270
E7018	Gray	All Positions	AC DC, Reverse (+)	Mild	High Rate	Smooth, Flat to Convex	72,000	70-100 80-120	90-150 110-170	120-190 135-225	170-280 200-300
E7028	Gray-Br	Flat Hor Fillets	AC DC, Reverse (+)	Mild	Very High Rate	Smooth and Slightly Cvx	72,000			180-270 170-240	240-330 210-300

*DC Reverse means DC, reverse polarity (electrode positive).
DC Straight means DC, straight polarity (electrode negative).

VII. Common electrode sizes

(NOTE: Electrodes range in size from 1/16" to 5/16".)

A. 3/32"

B. 1/8"

INFORMATION SHEET

C. 5/32"

D. 3/16"

E. 7/32"

F. 1/4"

G. 5/16"

VIII. Determining electrode size--Determined by diameter of bare end of electrode

IX. Purposes of flux coating on electrodes

A. Stabilizes arc

B. Shields molten puddle from air

C. Floats impurities out of puddle

D. Forms slag and slows cooling

E. Provides deoxidizers and scavengers to prevent porosity of weld zone

F. Provides alloying elements for higher strength welds

G. Provides iron powder to increase the disposition rate

X. Numbers in the AWS electrode classification (Transparency 2)

A. E--Stands for electrode

B. First two digits--Indicate tensile strength deposited in a thousand pounds per square inch

C. Third number--Indicates welding position

1. All positions

2. Flat and horizontal

D. Fourth digits--Represents special characterisitics and usability of the rod

1. Current

2. Penetration

3. Type of flux coating

INFORMATION SHEET

XI. Factors for selecting electrodes for a specific job application

- A. Base metal strength properties
- B. Base metal composition
- C. Welding position
- D. Welding current
- E. Joint design and fit-up
- F. Thickness and shape of base metal
- G. Service conditions and/or specification
- H. Production efficiency and job conditions

XII. Reasons for poor welds

- A. Improper machine adjustment
- B. Improper electrode and size
- C. Improper movement of electrode
- D. Improper angle of electrode
- E. Improper base metal preparation
- F. Improper arc length

XIII. Parts of welding process (Transparency 3)

- A. Slag
- B. Weld
- C. Electrode
- D. Wire core
- E. Coating
- F. Arc
- G. Crater

INFORMATION SHEET

   H. Penetration

   I. Base metal

   J. Heat lines

   K. Gaseous shield

   L. Ten degrees--fifteen degrees

XIV. Methods of striking an arc

   A. Tapping

   B. Scratching

XV. Safety lens range for electric welding--9-14

(NOTE: A safety lens within the 9 to 14 range will be adequate for all types of electric welding.)

XVI. Reasons for removing slag from a weld

   A. Permits better fusion of beads

   B. Prevents gas pockets and slag inclusions from forming in bead

   C. Improves appearance of bead

XVII. Reasons for fusing one bead in with another

   A. Increases strength of weld

   B. Improves appearance of bead

   C. Improves penetration

XVIII. Factors that determine weld quality

   A. Amperage

   B. Length of Arc

   C. Speed of travel

   D. Position of electrode

INFORMATION SHEET

XIX. Causes of improperly formed beads (Transparency 4)

A. Current low--Poor penetration, slow progress, excessive piling of weld metal

B. Current high--Excessive sputter, undercutting of weld joints

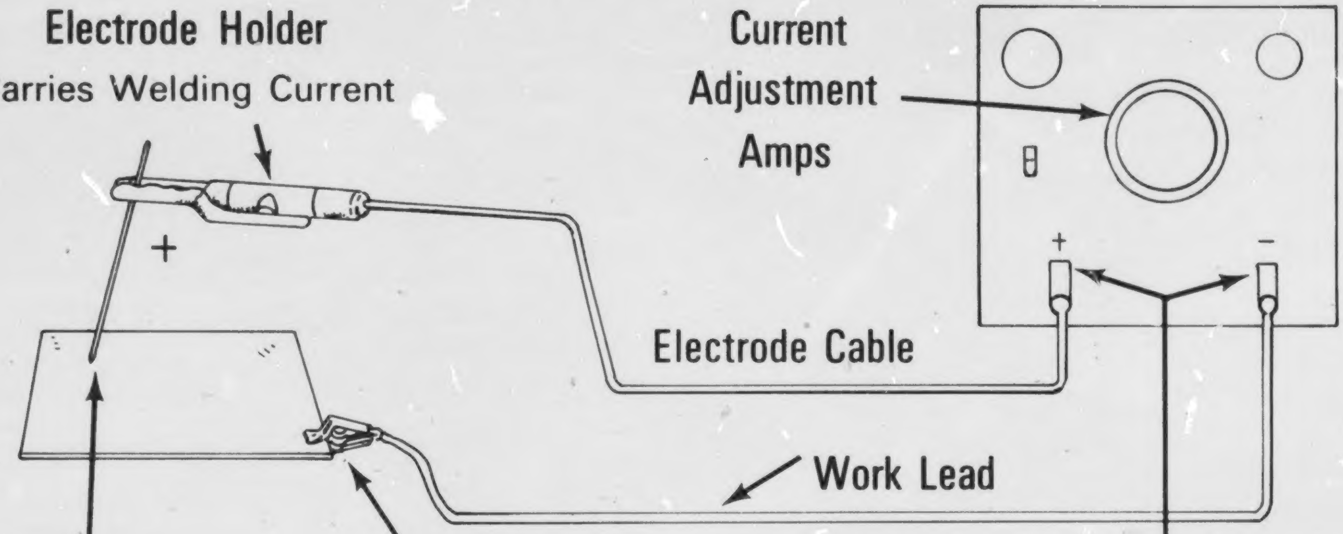
C. Voltage high--Poor penetration with flat bead, weld zone not shielded

D. Voltage low--Poor penetration, wide humped bead, electrode too close to crater causing porosity

E. Speed slow--Excessive heat, piling up of weld metal leading to unnecessary distortion of joint

F. Speed fast--Irregular bead, poor penetration, not enough weld metal in joint causing a weak joint

Welding Circuit



Welding Machine

Electrode Holder

Carries Welding Current

Current Adjustment Amps

+

+ −

Electrode Cable

Work Lead

Electrode

Diameters:
1/16 - 5/16 x 14′
Most Common
Length

Ground Clamp

Completes
Welding Circuit

Polarity-D.C. Current

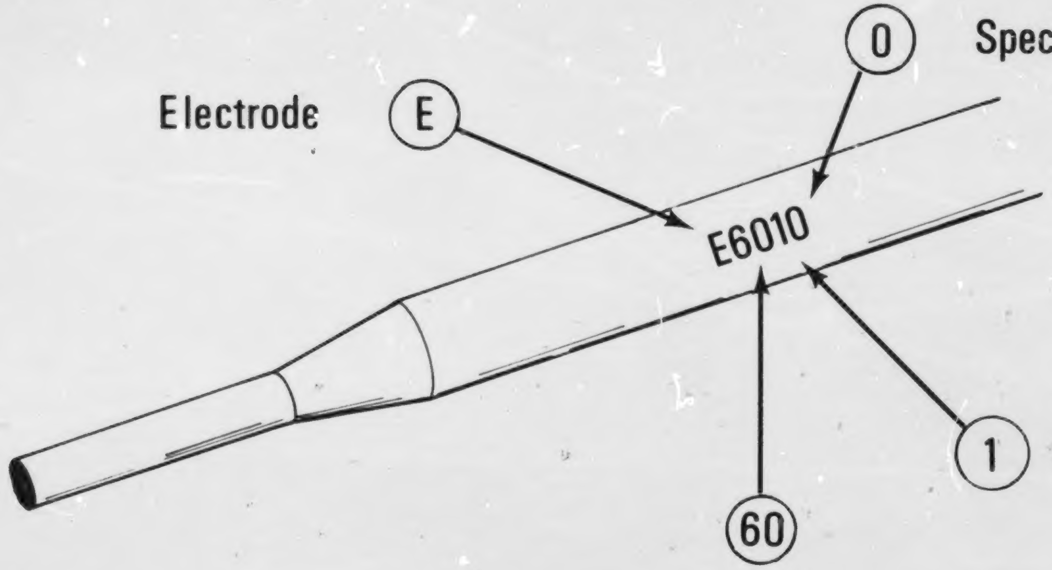
Reverse:

1. Electrode (+)
2. Current flows from work to electrode
3. 2/3 heat at (+) electrode
   1/3 heat at (-) work

Straight:

1. Electrode (-)
2. Current flows from electrode to work
3. 2/3 heat at (-) work
   1/3 heat at (+) electrode

Standardized AWS Classification



Electrode

Special Characteristics

current
penetration
type of flux
coating

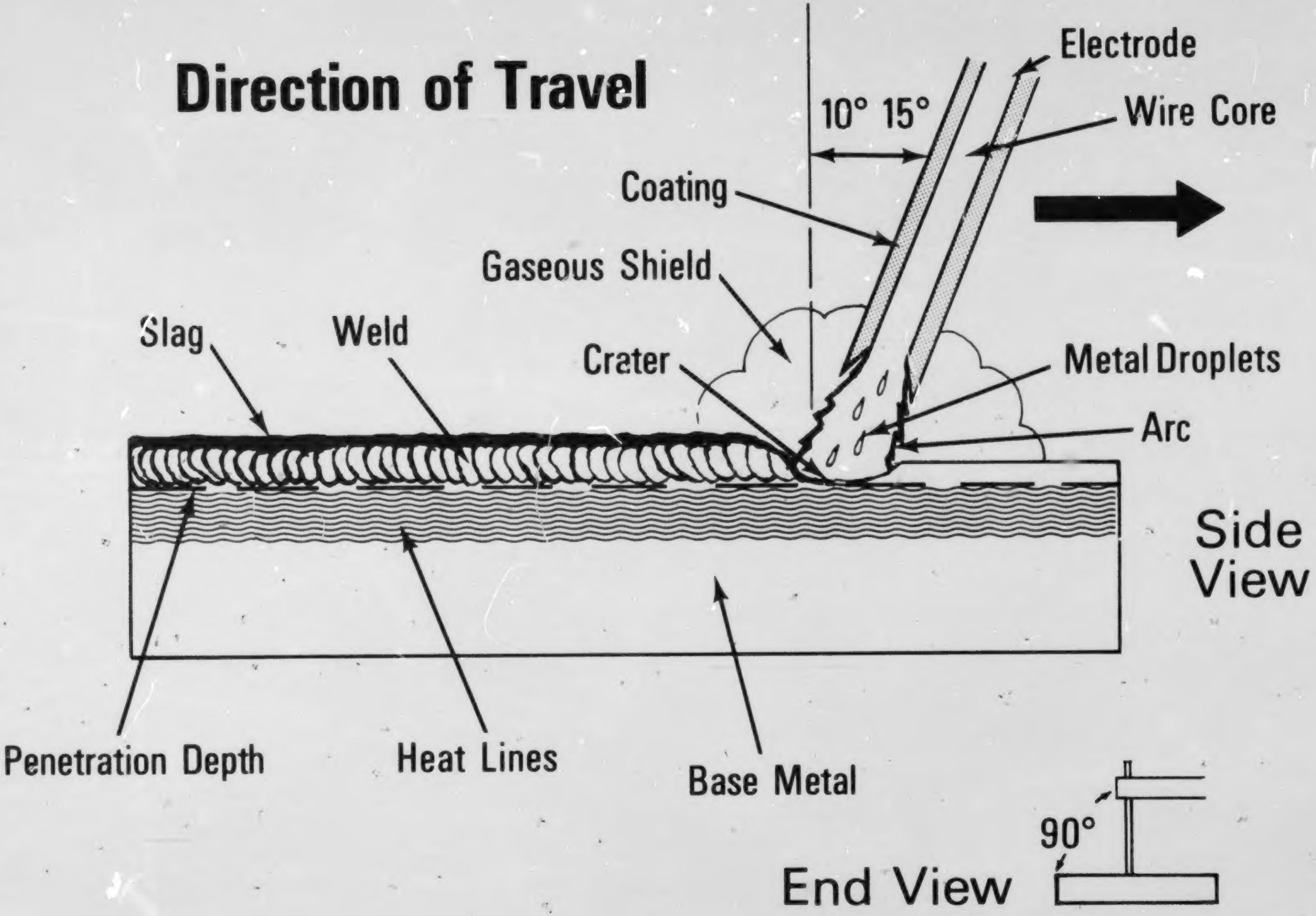
Welding Positions

1. all positions
2. flat and horizontal

Tensile Strength 1,000 Lbs. Per Sq. Inch

E6010 Mild Steel Electrode

Direction of Travel



Electrode

Wire Core

10° 15°

Coating

Gaseous Shield

Slag

Weld

Crater

Metal Droplets

Arc

Side View

Penetration Depth

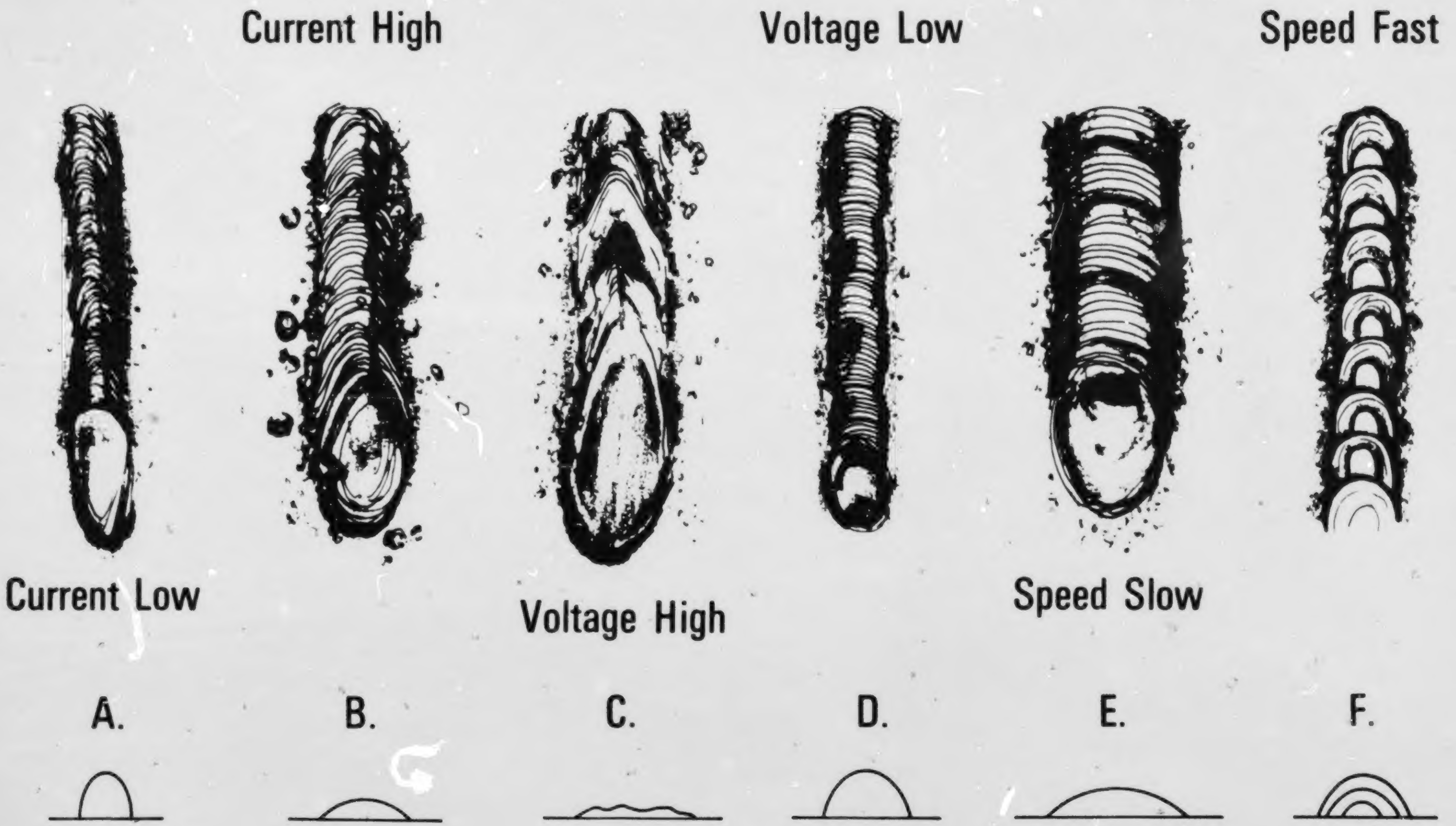
Heat Lines

Base Metal

90°

End View

Improperly Formed Beads


Current High
Voltage Low
Speed Fast
Current Low
Voltage High
Speed Slow
A.
B.
C.
D.
E.
F.

ELECTRIC WELDING
UNIT VI

JOB SHEET #1--START, STOP, AND RESTART A BEAD

I. Tools and materials

   A. Metal--1/4" to 3/8", 4" x 4"

   B. Welding machine and accessories

   C. Welding helmet

   D. Protective clothing

   E. E-6010 electrode--1/8" or 5/32"

      1. 1/8" - 75-130 amps

      2. 5/32" - 90-175 amps

   F. Current DCRP (+) at the electrode

   G. Chipping hammer

   H. Wire brush

II. Procedure

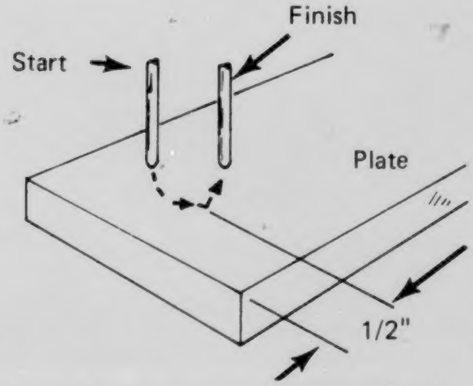
   A. Start the bead

      1. Adjust machine to desired welding current

         (NOTE: This desired current will depend on type and size of electrode, and thickness of metal. Refer to Chart #1.)

      2. Hold electrode perpendicular to work where weld is to start (Figure 1)

FIGURE 1



JOB SHEET #1

3. Slant electrode 10° to 15° in direction of travel

4. Lower electrode and tap or scratch lightly on edge of plate

   (NOTE: This procedure is necessary for establishing an arc.)

5. Momentarily raise electrode upon establishment of arc

   (NOTE: This preheats the edge of metal and prevents a cold start.)

6. Lower electrode to correct arc length

7. Rotate electrode

   (NOTE: Rotate the electrode to build up desired height of bead and to obtain desired width of bead. When desired crater develops, move out slowly using normal manipulation.)

B. Stop the bead

1. Return electrode to 90° or perpendicular to work

2. Reverse electrode and hold until crater fills

   (NOTE: This causes crater build up, removes impurities from weld, and prevents crater from cracking.)

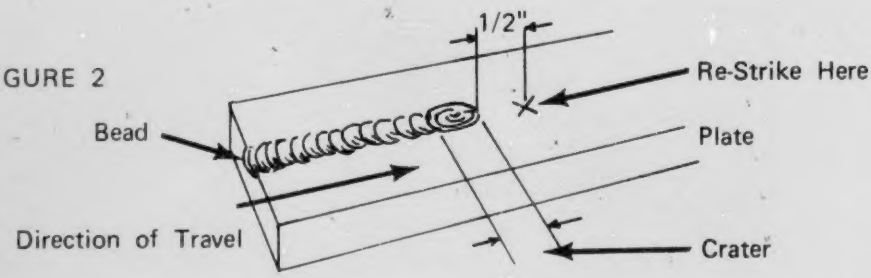
3. Raise electrode quickly when desired width and height of bead is formed

C. Restart the bead

1. Start arc about 1/2" to 3/4" in front of crater

2. With a long arc, move electrode back to within 1/16" of the crater crown, fill to bead size, and then resume normal travel (Figure 2)

FIGURE 2



JOB SHEET #1

3. Fuse new crater into last ripple of crater
4. Maintain correct width of bead while completing weld

(NOTE: Arc length is correct when it makes a "frying" noise. The force of the arc determines penetration and bead appearance.)

ELECTRIC WELDING
UNIT VI

JOB SHEET #2--MAKE A PAD IN THE FLAT POSITION

I. Tools and materials

- A. Mild steel metal 3/8" thick, 6" by 6"
- B. Welding machine and accessories
- C. Welding helmet
- D. Protective clothing
- E. E-6010 electrodes--1/8" or 5/32"
  - 1. 1/8"--75-130 amps
  - 2. 5/32"--90-175 amps
- F. Current DCRP (+) at the electrode
- G. Chipping hammer
- H. Wire brush
- I. Pliers

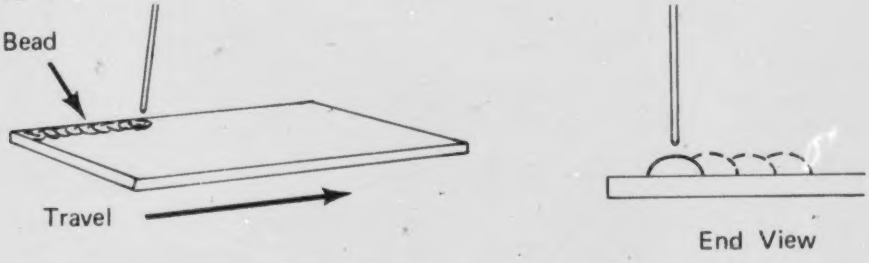
II. Procedure

- A. Set welding machine
- B. Prepare and place metal in flat position

  (NOTE: Remove all dirt, grease, and mill scale from surfaces of metal.)

- C. Run a straight bead near edge of plate (Figure 1)

FIGURE 1



(NOTE: For the first bead, the electrode should be held almost vertical. Do not use side angle.)

(CAUTION: Avoid burning off edge of plate.)

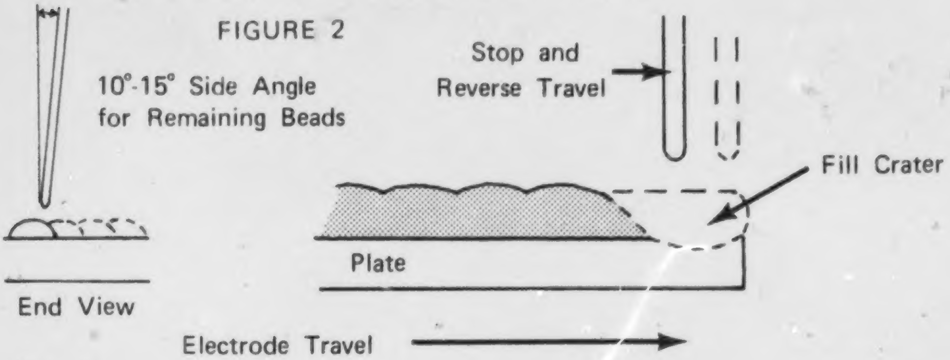
JOB SHEET #2

D. After laying first bead, chip and brush it clean and check surface

(NOTE: The surface appearance should be smooth and even. Check for pinholes, crater holes, slag holes, or indications of improper starts and stops. Also, checking the bead will identify if current needs to be changed.)

E. Reverse travel and run additional beads, remember to overlap at least the first one-third of the previous bead (Figure 2)

FIGURE 2


10°-15° Side Angle
for Remaining Beads
Stop and
Reverse Travel
Fill Crater
Plate
End View
Electrode Travel

(NOTE: The electrode should be held at 10° to 15° to the side for this bead and all other beads.)

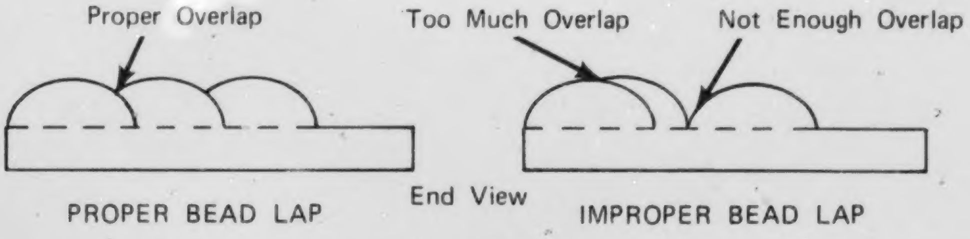
F. Clean each pass thoroughly before overlapping with another

(NOTE: This will insure a sound deposit with proper penetration and no slag holes.)

G. Fuse each pass with base metal as well as with the preceding pass (Figure 3)

(NOTE: Alternate travel direction for each pass.)

FIGURE 3


Proper Overlap
Too Much Overlap
Not Enough Overlap
PROPER BEAD LAP
End View
IMPROPER BEAD LAP

(NOTE: The overlapping beads should produce a comparatively smooth surface without noticeable "valleys" between passes.)

H. Continue running beads until pad is full

I. Clean the piece of metal thoroughly and have instructor inspect

ELECTRIC WELDING
UNIT VI

JOB SHEET #3--MAKE A SQUARE GROOVE BUTT WELD

I. Tools and materials

   A. Two pieces of metal 3/16" to 1/4" thick, 2" wide, and 6" long

   B. Welding machines and accessories

   C. Welding helmet

   D. Protective clothing

   E. E-6010--1/8" or 5/32"

      1. 1/8"--75-130 amps

      2. 5/32"--90-175 amps

   F. Current DCRP (+) at the electrode

   G. Safety goggles

   H. Chipping hammer

   I. Wire brush

II. Procedure

   A. Adjust welding machine to correct welding current

   B. Prepare metal for welding by removing dirt, grease, or mill scale

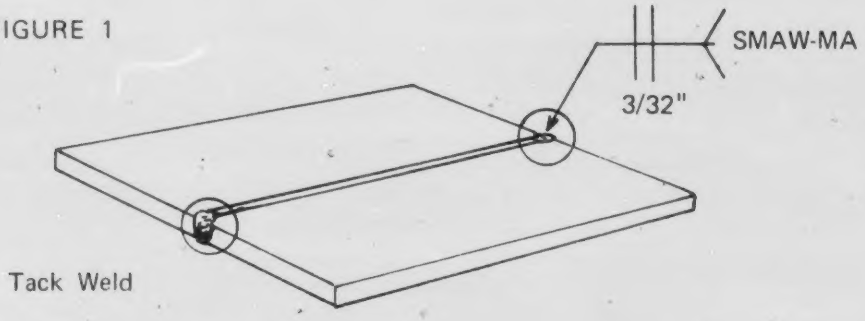
   C. Place metal together parallel to each other, leaving a space 3/32"

   (NOTE: The proper space can be determined by placing the bare end of a 3/32" electrode between the two pieces of metal.)

JOB SHEET #3

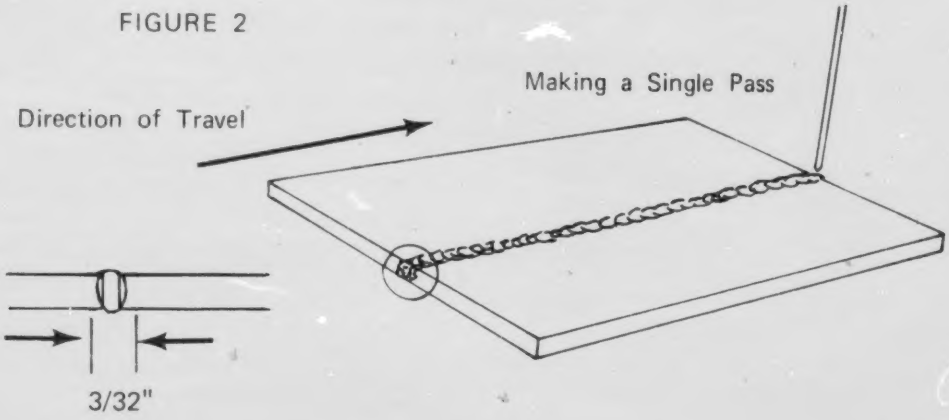
D. Tack weld pieces together at both ends (Figure 1)

FIGURE 1


SMAW-MA
3/32"
Tack Weld

E. Weld pieces together using a single pass on one side for 100% penetration (Figure 2)

FIGURE 2


Making a Single Pass
Direction of Travel
3/32"

F. Chip slag, brush weld, and check for complete penetration at the root of weld

ELECTRIC WELDING
UNIT VI

JOB SHEET #4--MAKE A MULTIPLE PASS T-JOINT FILLET WELD

I. Tools and materials

   A. Arc welding station and required tools

   B. Mild steel plate-2 pieces 1/4" to 3/8", 3" x 6"

   C. Electrode E-5010 1/8" or 5/32"

      1. 1/8" - 75-130 amps

      2. 5/32" - 90-175 amps

   D Current DCRP (+) at electrode

   E. Protective clothing

II. Procedure

   A. Adjust welding machine to correct current and amperage

   B. Position plates on table to form a T-joint

   C. Tack plates on each end and remove slag

   D. For first bead, angle electrode 45° from vertical plate and 5°-10° in direction of travel (Figure 1)

Multiple Pass Fillet Weld

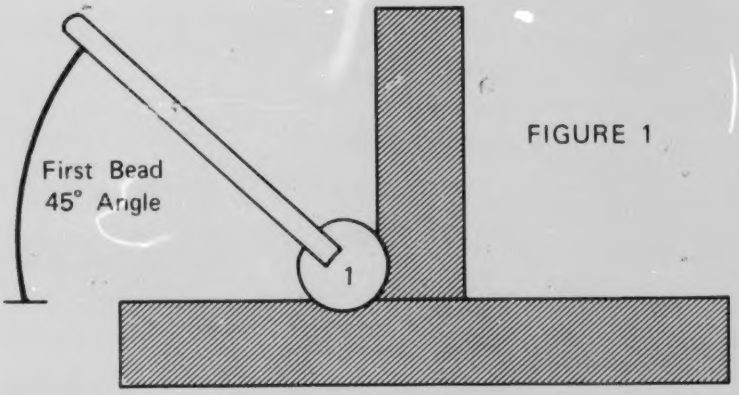


FIGURE 1

JOB SHEET #4

E. Strike arc at end of plate holding a high arc for 1 or 2 seconds

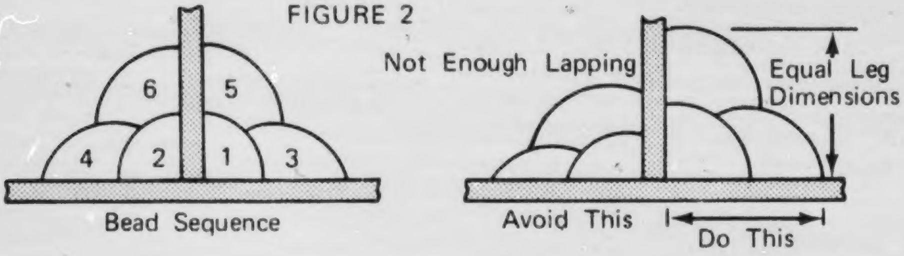
(NOTE: This allows for the end of the metal plates to heat prior to depositing the proper beads and prevents cold lap.)

F. Move electrode to opposite side of T-joint and start depositing second bead using same angle used in bead one

G. Deposit beads about two times wider than electrode diameter

(NOTE: Remember to alternate passes from one side to another of T-joint to minimize distortion of the plates. See Figure 2.)

FIGURE 2



Bead Sequence

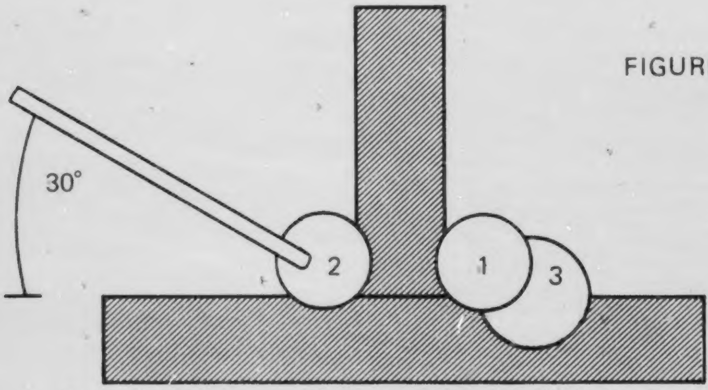
Keep Bead Dimensions Constant

H. Remove slag from bead one and two

(NOTE: Keep each bead dimension constant. It is necessary to overlap beads more than seems necessary to avoid laying too much on bottom by side of joint.)

I. Deposit bead three using a 30° angle from horizontal plate with the electrode slanting 5° to 10° in direction of travel (Figure 3)

FIGURE 3



Deposit Beads on Alternate Sides to Minimize Distortion

JOB SHEET #4

J. Deposit bead four using same angle as used in depositing bead three (Figure 4)

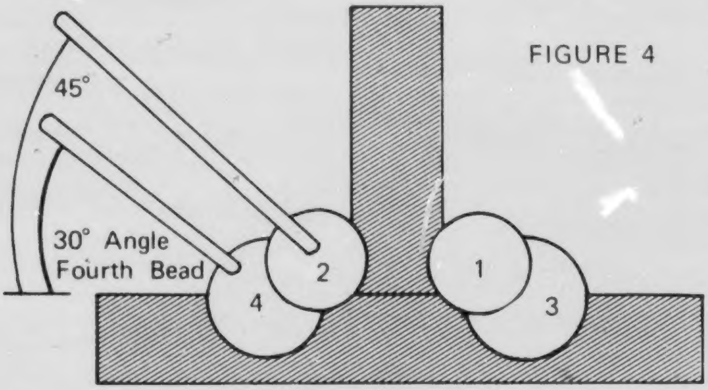

45°
30° Angle
Fourth Bead
2
4
1
3

FIGURE 4

K. Deposit bead five using a 70° degree angle from vertical plate with the electrode slanting 5° to 10° in direction of travel (Figure 5)

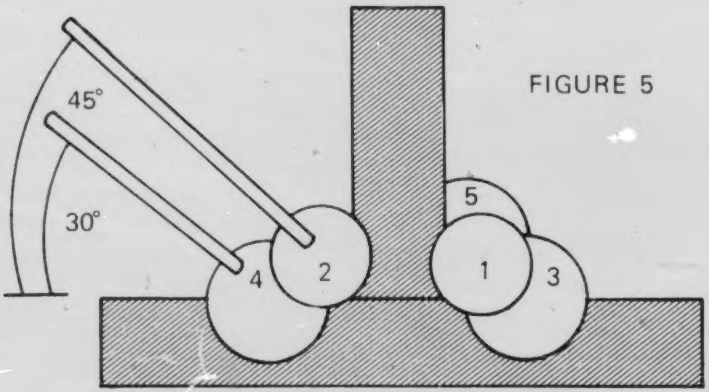


FIGURE 5

JOB SHEET #4

L. Deposit bead six using same angle as used in bead five (Figure 6)

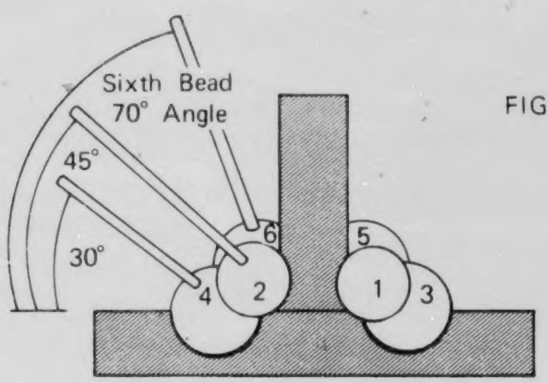

Sixth Bead
70° Angle
45°
30°
6
5
4
2
1
3

FIGURE 6

M. After completing required number of passes, have instructor inspect (Figure 7)

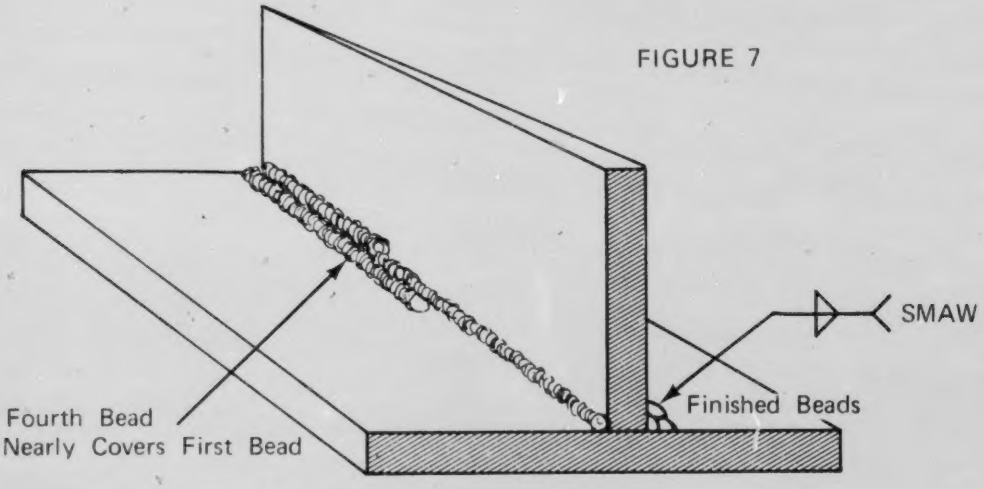

SMAW
Finished Beads
Fourth Bead
Nearly Covers First Bead

FIGURE 7

ELECTRIC WELDING
UNIT VI

TEST

1. Match the terms on the right to the correct definitions.

______a. Exposed surface of a weld, made by an arc or gas welding process, on the side from which welding was done

______b. Arc welding process wherein metals are united by heating with an electric arc between a coated metal electrode and the metal

______c. Depression at the termination of a weld

______d. Distance from the end of the electrode to the point where the arc makes contact with work surface

______e. Metal to be welded or cut

______f. Fusible material or gas used to dissolve and/or prevent the formation of oxides, nitrides, or other undesirable inclusions formed in welding

______g. That portion of a weld that is molten at the place the heat is supplied

______h. Weld made to hold parts in proper alignment until the final welds are made

______i. Steel containing .20% or less carbon

______j. Metal particles given off during welding which do not form a part of the weld

______k. Single longitudinal progression of a welding operation along a joint or weld deposit

______l. Gas pockets or voids in metal

1. Whipping
2. Shielded metal arc welding
3. Weld metal
4. Weaving
5. Undercut
6. Base metal
7. Puddle
8. Arc length
9. Tack weld
10. Crater
11. Spatter
12. Face of weld
13. Porosity
14. Flux
15. Pass
16. Low carbon steel
17. AWS
18. Disposition rate

______m. Term applied to an inward and upward movement of the electrode which is employed in vertical welding to avoid undercut

______n. Groove melted into the base metal adjacent to the toe of the weld and left unfilled by weld metal

______o. That portion of a weld which has been melted during welding

______p. Technique of depositing weld metal in which the electrode is oscillated

______q. American Welding Society

______r. Amount of filler metal deposited in any welding process; rate is in pounds per hour

2. Name four types of arc welding machines.

   a.

   b.

   c.

   d.

3. Distinguish between straight and reverse polarity by placing an "X" before the statement that signifies reverse polarity.

   ______a. Current flows from electrode to base metal

   ______b. Current flows from base metal to electrode

4. Name the two types of operating adjustments found on arc welding machines.

   a.

   b.

5. Discuss how to test for polarity.

6. Name four common types of electrodes.

   a.

   b.

   c.

   d.

7. Name four common sizes of electrodes.

   a.

   b.

   c.

   d.

8. Select the statement which determines electrode size by placing an "X" in the appropriate blank.

   ______a. Length of electrode

   ______b. Diameter of bare end of electrode

   ______c. Type of flux on electrode

9. Select the purposes of flux coating on electrodes by placing an "X" in the appropriate blanks.

   ______a. Stabilizes arc

   ______b. Makes arc starting difficult

   ______c. Shields molten puddle from air

   ______d. Provides deoxidizers and scavengers to prevent porosity of weld zone

   ______e. Keeps moisture out of filler metal

   ______f. Forms slag and slows cooling

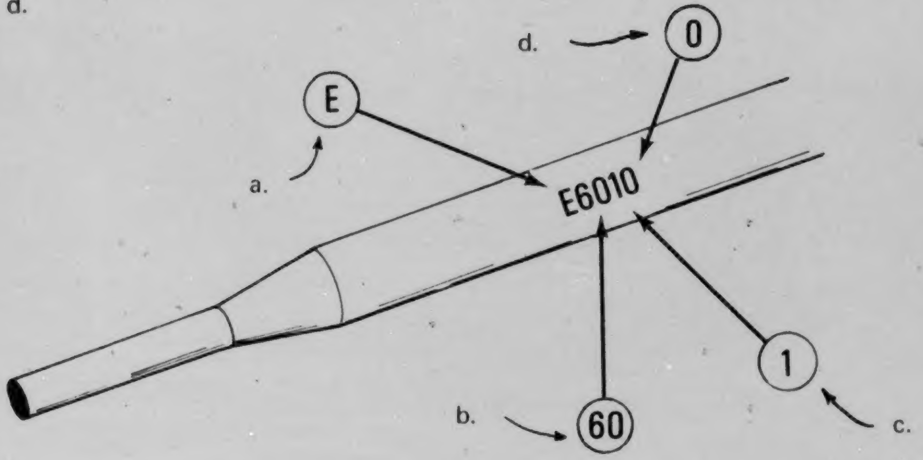
10. Identify the numbers in the AWS electrode classification.

a.

b.

c.

d.



11. Name five factors to be considered when selecting an electrode for a specific job application.

a.

b.

c.

d.

e.

12. Select the reasons for poor welds by placing an "X" in the appropriate blanks.

______a. Improper angle of electrode

______b. Improper electrode and size

______c. Improper machine adjustment

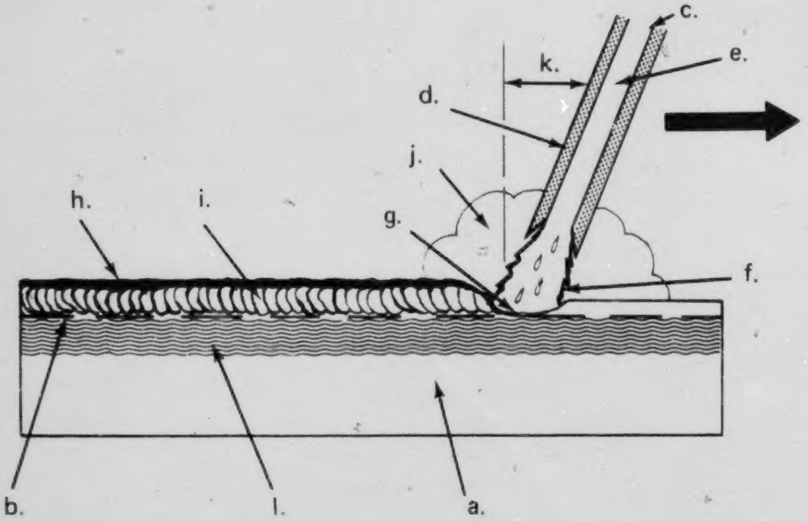
______d. Improper clamping of electrode in holder

______e. Welding from left to right with the forehand technique ______f. Improper base metal prepartion

______g. Running a E-6010 electrode on DCRP

______h. Improper arc length

13. Identify the parts of the welding process.



a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

k.

l.

14. Name the two methods of striking an arc.

a.

b.

15. State the correct range of lens shade number for electric welding.

16. Select reasons for removing slag from a weld by placing an "X" in the appropriate blanks.

______a. Prevents better fusion of beads

______b. Prevents penetration

______c. Prevents gas pockets and slag inclusions from forming in bead

______d. Improves appearance of bead

______e. Causes irregular arc

17. Name three reasons for fusing one bead in with another.

a.

b.

c.

18. Name four factors that determine weld quality.

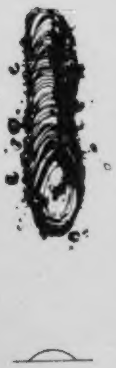
a.

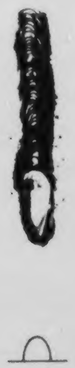
b.

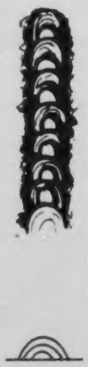
c.

d.

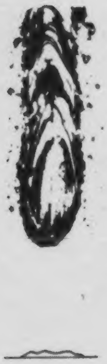
19. Identify the following examples of improperly formed beads by telling what caused each one.

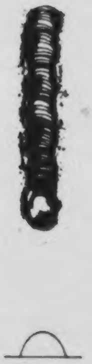


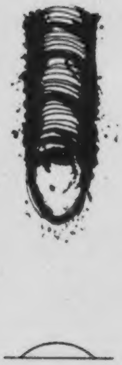




a. ______________ b. ______________ c. ______________







d. ____________ e. ____________ f. ____________

20. Demonstrate the ability to:

  a. Start, stop, and restart a bead.

  b. Make a pad in the flat position.

  c. Make a square groove butt weld.

  d. Make a multiple pass T-joint fillet weld.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

ELECTRIC WELDING
UNIT VI

ANSWERS TO TEST

1. a. 12
   b. 2
   c. 10
   d. 8
   e. 6
   f. 14
   g. 7
   h. 9
   i. 16
   j. 11
   k. 15
   l. 13
   m. 1
   n. 5
   o. 3
   p. 4
   q. 17
   r. 18

2. a. AC (alternating current) transformer welder
   b. AC-DC transformer rectifier
   c. Motor generator
   d. Engine generator

3. b

4. a. Current (amperage) settings
   b. Polarity

5. Discussion should include:
   a. Weld a bead using E-6010 reverse polarity electrode
   b. Strike arc with carbon electrode

6. Any four of the following:
   a. Mild steel
   b. Low hydrogen--low alloy
   c. Nonferrous
   d. Hard surfacing
   e. Cast iron
   f. Stainless steel

7. Any four of the following:
    a. 3/32"
    b. 1/8"
    c. 5/32"
    d. 3/16"
    e. 7/32"
    f. 1/4"
    g. 5/16"
8. b
9. a, c, d, f
10. a. Electrode
    b. Tensile strength deposited in thousand pounds per square inch
    c. Welding position
        1) All positions
        2) Flat and horizontal
    d. Special characteristics and usability of the rod
        1) Current
        2) Penetration
        3) Type of flux coating
11. Any five of the following:
    a. Base metal strength properties
    b. Base metal composition
    c. Welding position
    d. Welding current
    e. Joint design and fit-up
    f. Thickness and shape of base metal
    g. Service conditions and/or specification
    h. Production efficiency and job conditions

12. a, b, c, f, h

13.
    a. Base metal
    b. Penetration
    c. Electrode
    d. Coating
    e. Wire core
    f. Arc
    g. Crater
    h. Slag
    i. Weld
    j. Gaseous shield
    k. Ten degrees--fifteen degrees
    l. Heat lines

14.
    a. Tapping
    b. Scratching

15. 9-14

16. c, d

17.
    a. Increases strength of weld
    b. Improves appearance of bead
    c. Improves penetration

18.
    a. Amperage
    b. Length of arc
    c. Speed of travel
    d. Position of electrode

19. a. Current high
    b. Current low
    c. Speed fast
    d. Voltage high
    e. Voltage low
    f. Speed slow

20. Performance skills evaluated to the satisfaction of the instructor

PROGRESS CHART

Soldering and Welding

Date ______________________

Air Conditioning and Refrigeration

Section E

What The Trainee Should Be Able To Do

	Names	Light and adjust the air-acetylene torch	Light and adjust the halide torch leak detector	Light and adjust the oxyacetylene torch	Clean, flux, and solder a swage joint	Solder an inverted swage joint	Solder a horizontal swage joint	Soft solder with the Oxyacetylene torch	Silver braze an upright swage joint	Silver braze an inverted swage joint	Silver braze a horizontal swage joint	Silver braze a copper to steel joint	Silver braze a joint while circulating dry nitrogen	Silver braze the tubing project	Solder aluminum tubing	Solder aluminum tubing to copper tubing	Aluminum braze a hole in aluminum tubing
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PROGRESS CHART

Date

Names	What The Trainee Should Be Able To Do											
	Start, stop, and restart a bead	Make a pad in the flat position	Make a square groove butt weld	Make a multiple pass T-Joint Fillet Weld	Set up equipment for oxyacetylene cutting	Turn on light, adjust to a neutral flame and turn off the oxyacetylene cutting equipment	Make 90° cuts in mild steel and restart a cut	Cut a hole in mild steel	Lay beads on gauge metal without filler rod	Lay beads on gauge metal with filler rod	Weld butt joints with filler rod	Braze weld a square groove butt joint
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PROGRESS CHART

Soldering and Welding

Date ____________

Air Conditioning and Refrigeration

Section E

What The Trainee Should Be Able To Do

Names	Light and adjust the air-acetylene torch	Light and adjust the halide torch leak detector	Light and adjust the oxyacetylene torch	Clean, flux, and solder a swage joint	Solder an inverted swage joint	Solder a horizontal swage joint	Soft solder with the oxyacetylene torch	Silver braze an upright swage joint	Silver braze an inverted swage joint	Silver braze a horizontal swage joint	Silver braze a copper to steel joint	Silver braze a joint while circulating dry nitrogen	Silver braze the tubing project	Solder aluminum tubing	Solder aluminum tubing to copper tubing	Aluminum braze a hole in aluminum tubing
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PROGRESS CHART

Date

What The Trainee Should Be Able To Do

Names	Start, stop, and restart a bead	Make a pad in the flat position	Make a square groove butt weld	Make a multiple pass T-Joint Fillet Weld	Set up equipment for oxyacetylene cutting	Turn on light, adjust to a neutral flame and turn off the oxyacetylene cutting equipment	Make 90° cuts in mild steel and restart a cut	Cut a hole in mild steel	Lay beads on gauge metal without filler rod	Lay beads on gauge metal with filler rod	Weld butt joints with filler rod	Braze weld a square groove butt joint												
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BASIC MECHANICAL REFRIGERATION
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify compressors, evaporators, condensers, and connecting refrigerant lines, select the types of metering devices and indicate the state of the refrigerant at various points in the refrigeration system. The student should be able to draw and assemble a basic refrigeration system, label all components and show direction of refrigerant flow. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match refrigeration terms to the correct definition or description.
2. Identify types of compressors.
3. Identify types of evaporators.
4. Identify types of condensers.
5. Select the types of metering devices commonly in use.
6. Identify all connecting refrigerant lines.
7. Select the state the refrigerant is in at various points in the refrigeration system.
8. Demonstrate the ability to:
    a. Draw a basic refrigeration system.
    b. Assemble a basic refrigeration system.

BASIC MECHANICAL REFRIGERATION
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information, assignment, and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information, assignment, and job sheets.

   F. Show students actual components such as compressors, evaporators, metering devices, and line sets.

   G. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete assignment and job sheets.

   D. Make sure you are able to identify the various components by sight, description, and application.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Hermetic Reciprocal Compressors

      2. TM 2--Semi-Hermetic and Open Reciprocal Compressors

   3. TM 3--Hermetic Rotary Compressors
   4. TM 4--Evaporators
   5. TM 5--Air Cooled Condensers
   6. TM 6--Water Cooled Condensers
   7. TM 7--Metering Devices
   8. TM 8--Refrigerant Lines
   9. TM 9--Complete Basic Refrigeration System

D. Assignment Sheet #1--Draw a Basic Refrigeration System

E. Job Sheet #1--Assemble a Basic Refrigeration System

F. Test

G. Answers to test

II. References:

A. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Company, Inc., 1975.

B. Weaver, Michael K., and Kirkpatrick, James M. *Environment Control.* New York: Harper and Row, 1974.

III. Additional references--Laub, Julian M. *Air Conditioning and Heating Practice.* San Francisco, California: Rinehart Press, 1963.

BASIC MECHANICAL REFRIGERATION
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Compressor--Pump of a refrigerating mechanism which draws a vacuum or low pressure on the cooling portion of the refrigerant cycle and compresses the vaporized refrigerant into the high pressure side of the system

B. Reciprocal compressor--Compressor which uses a piston and cylinder mechanism to provide pumping action

C. Rotary compressor--Compressor which uses vanes, eccentric mechanisms, or other rotating devices to provide pumping action

D. Hermetic compressor--Compressor in which the driving motor is sealed in the same welded dome that contains the compressor

E. Semi-hermetic compressor--Compressor in which the driving motor is sealed in the same bolted housing that contains the compressor

(NOTE: This compressor may be disassembled for internal repair by removing the bolts in the housing.)

F. Open compressor--Compressor in which the crankshaft extends through the crankcase and is driven by an outside motor

G. Evaporator--Part of a refrigerating mechanism in which the refrigerant vaporizes and absorbs heat

H. Shelf-type evaporator--The refrigerant flows through a series of coils formed to make the shelves on which products are stored

(NOTE: Another variation of this evaporator is called a plate, which has a metal plate pressed onto the coils.)

I. Shell-type evaporator--The evaporator coils are mounted in the walls of the freezer compartment which provides a larger cooling surface

Example: Chest type freezer

J. Fin-type evaporator--These evaporators have fins attached to the tubing which gives a larger cooling surface

(NOTE: These evaporators usually have a fan to circulate the air.)

INFORMATION SHEET

K. Condenser--Part of a refrigeration system which receives hot, high pressure refrigerant vapor from the compressor and removes heat from the refrigerant until it returns to a liquid state

L. Natural convection condenser--Condenser which transfers heat to the surrounding air by means of natural air flow

(NOTE: This is also called a static condenser.)

M. Forced convection condenser--A condenser which transfers heat to the surrounding air through the use of a fan or blower

(NOTE: This is also called a forced air condenser.)

N. Tube-within-a-tube condenser--Condenser which is constructed by placing one tube inside a second tube

(NOTE: The outer tube circulates refrigerant while the inner tube circulates the cooling water in opposite directions, also referred to as counterflow.)

O. Shell and tube condenser--Hot vaporized refrigerant is fed into the top of the shell and comes into contact with the cool water tubes and condenses the refrigerant

P. Evaporative condenser--A device which uses open spray or spilled water to cool a condenser

Q. Metering device--Any device that meters or regulates the flow of liquid refrigerant to an evaporator and also divides the high from the low pressure side of the system

R. Capillary tube--Refrigerant control usually consisting of a predetermined length of tubing having a small inside diameter

S. Thermostatic expansion valve--A metering device operated by temperature and pressure

T. Automatic expansion valve--A pressure controlled metering device which operates in response to evaporator pressure

U. Refrigerant lines--Lines required to carry the refrigerant liquid and vapor between the system components

(NOTE: These lines are made of copper, steel, aluminum, or rubber.)

V. Refrigerant--A substance used in refrigerating mechanisms to absorb heat in the evaporator

INFORMATION SHEET

W. Vapor state--State of refrigerant that has absorbed a maximum amount of heat

(NOTE: Heat laden refrigerant should be referred to as being vapor rather than gas.)

X. Liquid state--State of refrigerant that can absorb an additional amount of heat

II. Types of compressors (Transparencies 1, 2, and 3)

A. Reciprocal

1. Hermetic

2. Semi-hermetic

3. Open

B. Rotary

(NOTE: All rotary compressors in general use are hermetic.)

III. Types of evaporators (Transparency 4)

A. Shelf-type evaporator

(NOTE: Shelf-type evaporators are found in domestic and commercial refrigerators and freezers.)

B. Shell-type evaporator

(NOTE: Shell-type evaporators are found in domestic refrigerators and freezers and commercial freezers.)

C. Fin-type evaporator

(NOTE: Fin-type evaporators are found in domestic and commercial refrigerators, freezers, and air conditioners.)

IV. Types of condensers (Transparencies 5 and 6)

A. Air cooled

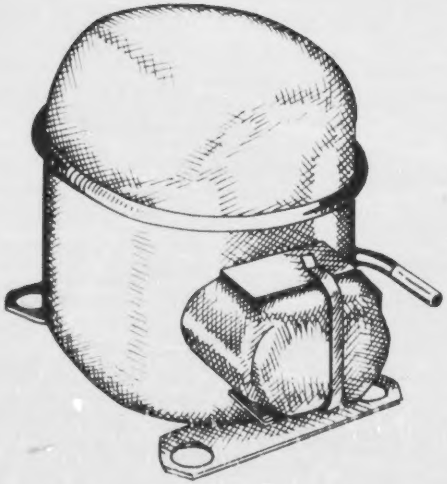
1. Natural convection (static)

2. Forced convection (blower)

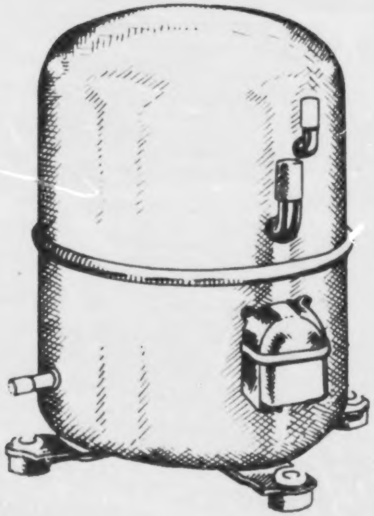
INFORMATION SHEET

- B. Water cooled
    - 1. Tube-within-a-tube
    - 2. Shell and tube
    - 3. Evaporative
- V. Metering devices (Transparency 7)
    - A. Capillary tube
    - B. Thermostatic expansion valve
    - C. Automatic expansion valve
- VI. Refrigerant lines (Transparency 8)
    - A. Discharge line
    - B. Liquid line
    - C. Suction line
- VII. State of refrigerant (Transparency 9)
    - A. Vapor
        - 1. Outlet of evaporator
        - 2. Compressor dome
        - 3. Suction line
        - 4. Discharge line
        - 5. Top of condenser
    - B. Liquid
        - 1. Bottom of condenser
        - 2. Liquid line
        - 3. Inlet of evaporator

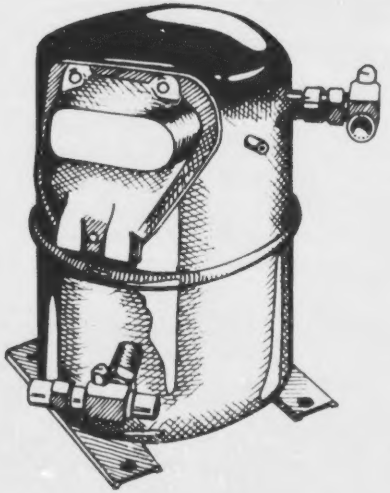
Hermetic Reciprocal Compressors



Domestic Refrigerators and Freezers



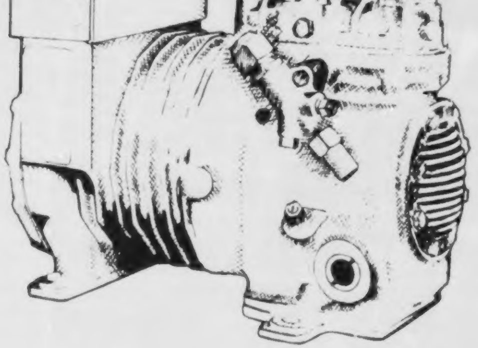
Window Air Conditioners



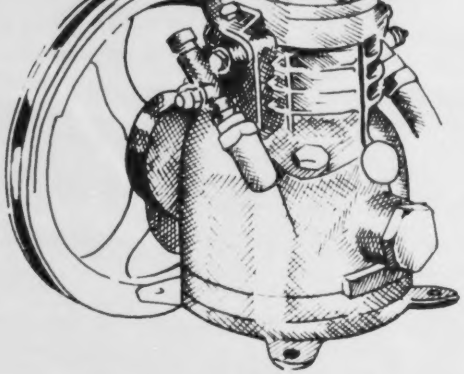
Central Air Conditioners

Semi-Hermetic and Open Reciprocal Compressors

Semi-Hermetic



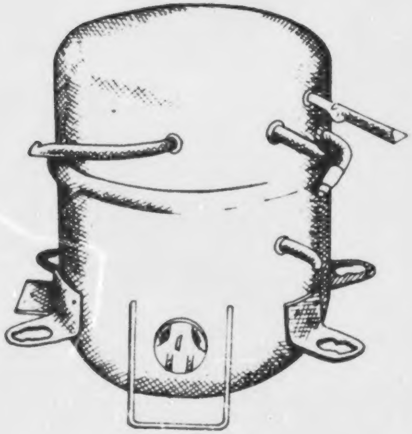
Open

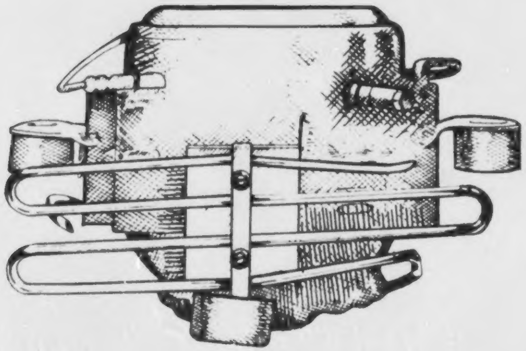


Hermetic Rotary Compressors

Domestic Refrigerators and Freezers

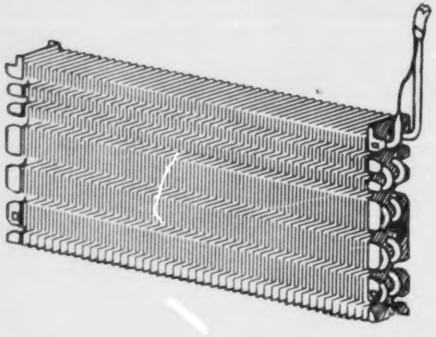
Commercial Ice Makers



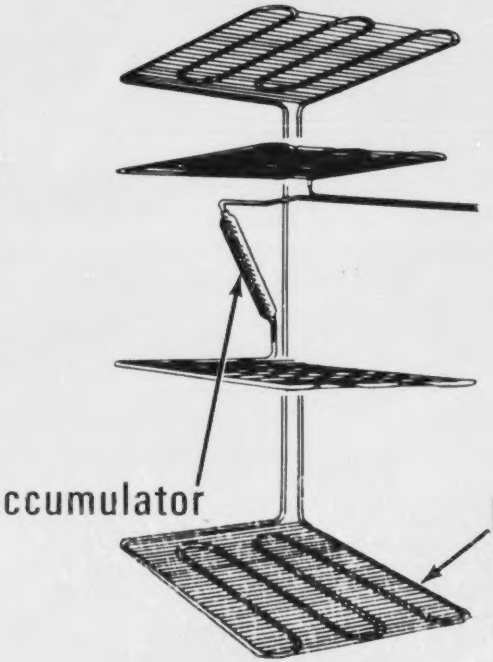


Evaporators

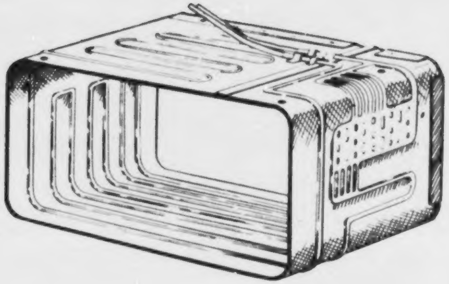
Fin



Shelf

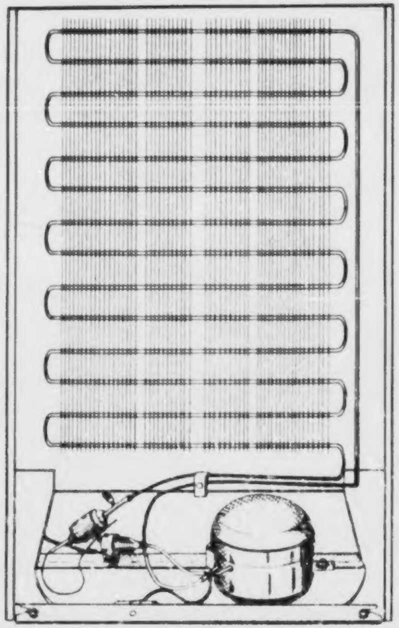

Accumulator
Evaporator

Shell

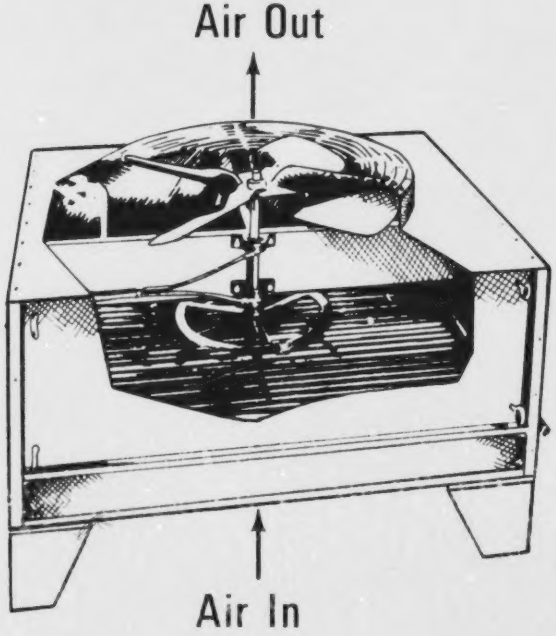


Air Cooled Condensers

Natural Convection (Static)

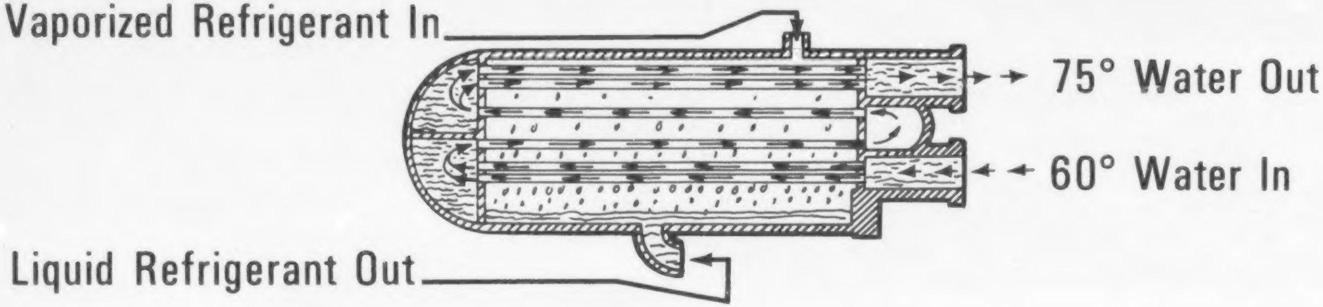


Forced Convection

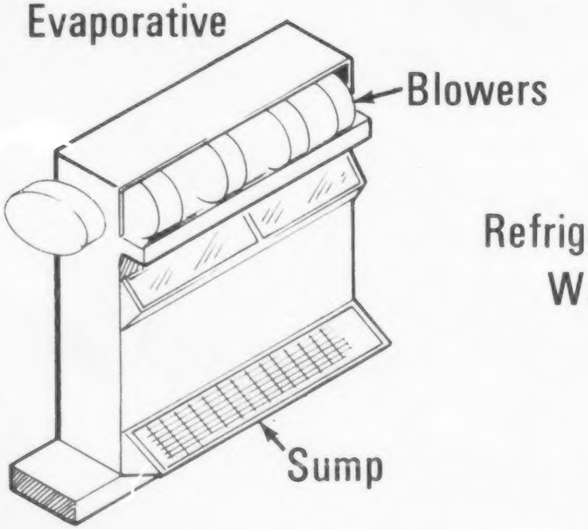

Air Out
Air In

Water Cooled Condensers

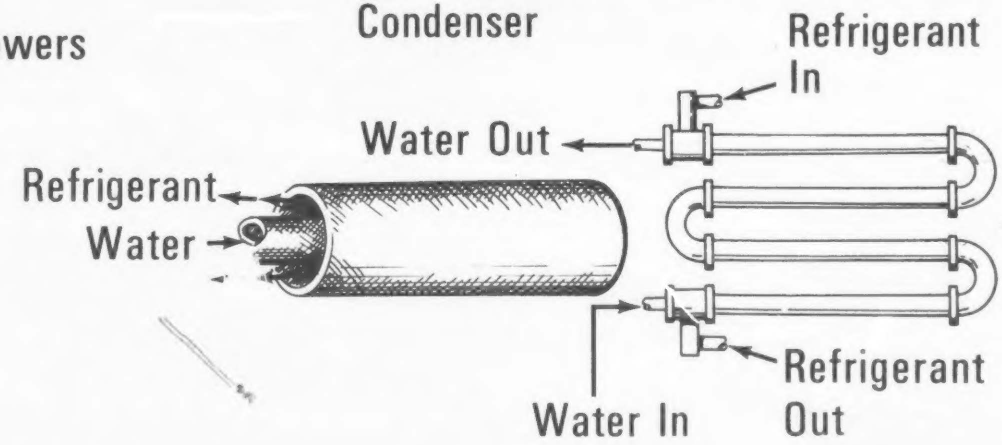
Shell and Tube


Vaporized Refrigerant In
75° Water Out
60° Water In
Liquid Refrigerant Out

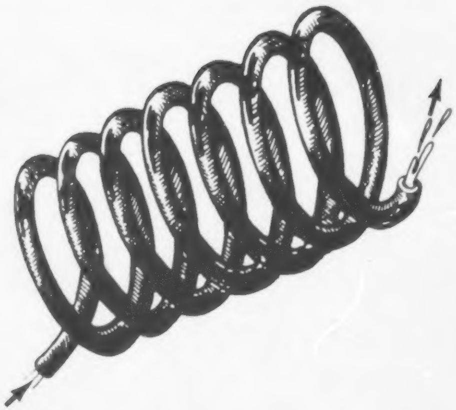
Evaporative


Blowers
Sump

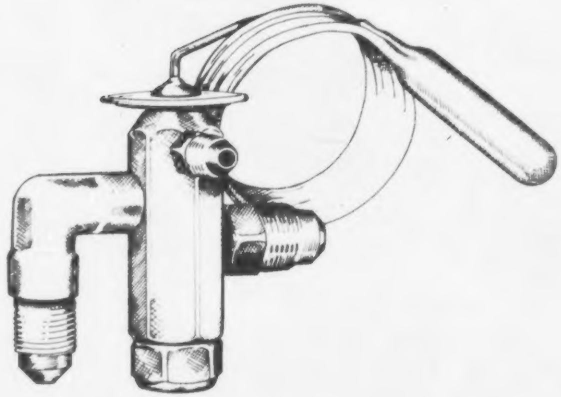
Tube-Within-a-Tube Condenser


Refrigerant In
Water Out
Refrigerant
Water
Refrigerant Out
Water In

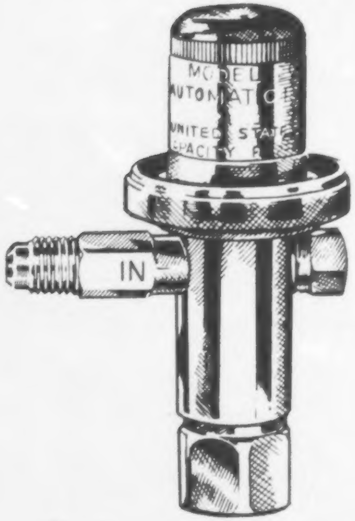
Metering Devices



Capillary Tube



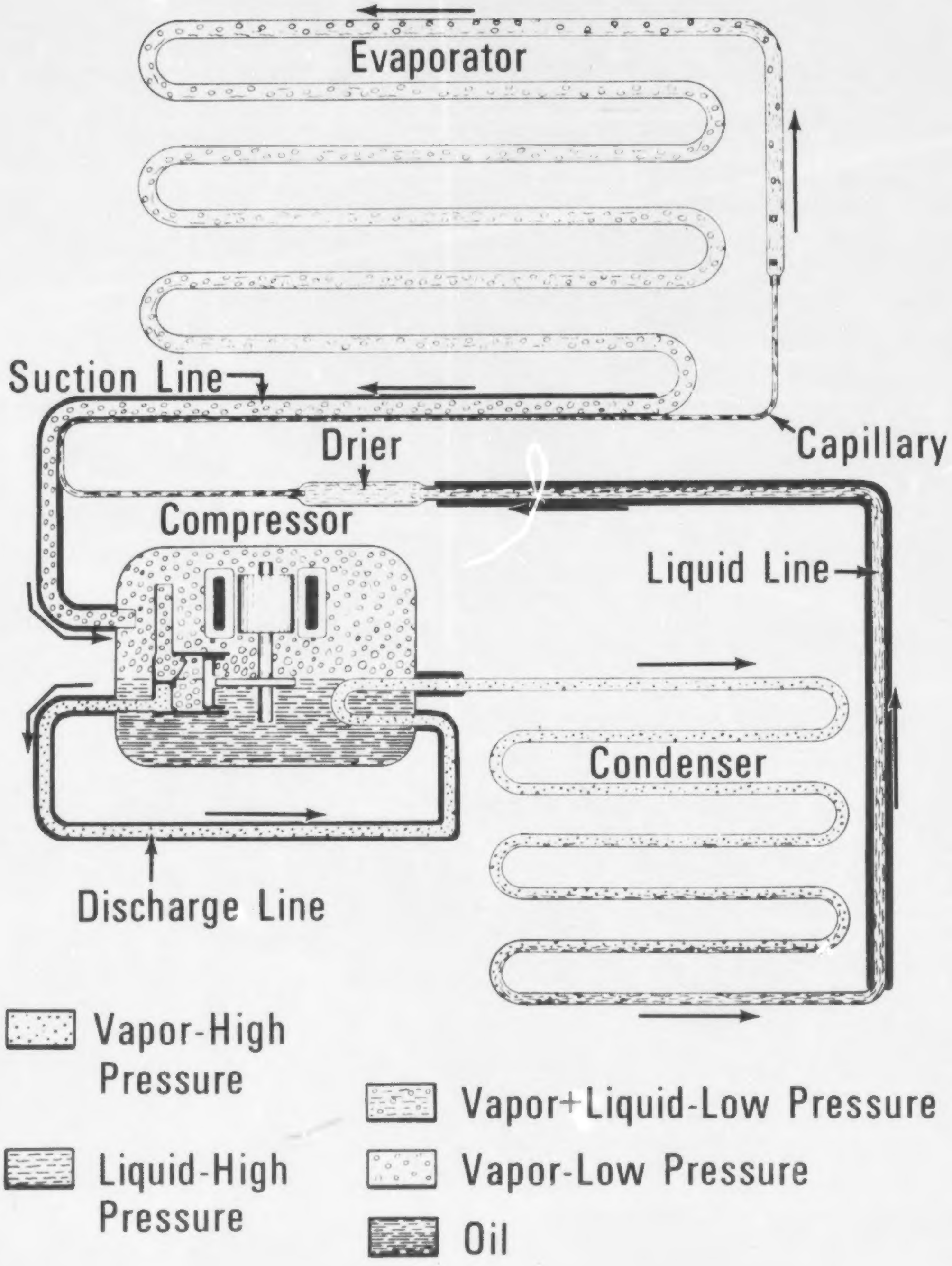
Thermostatic Expansion Valve



Automatic Expansion Valve

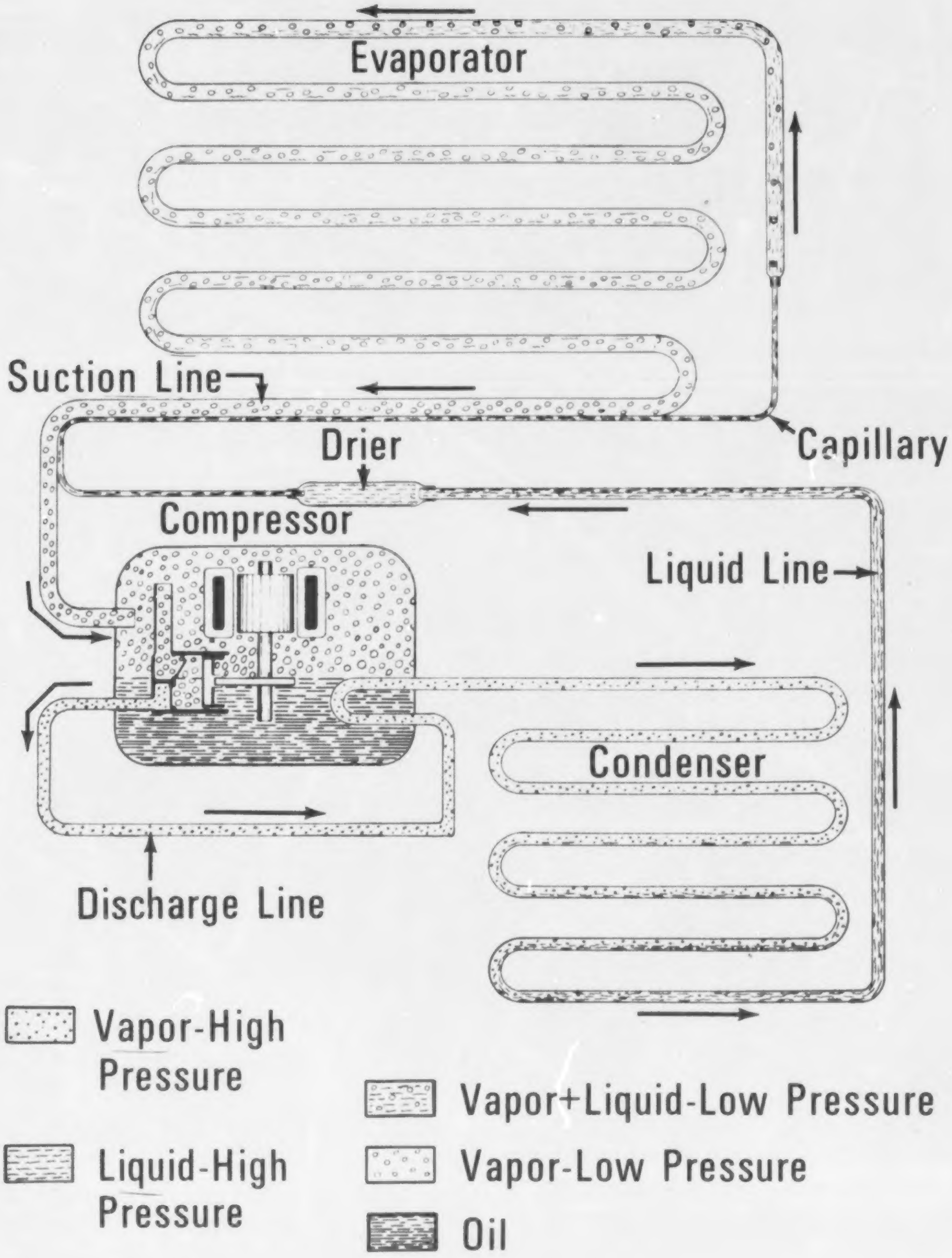
Refrigerant Lines

Refrigeration Cycle


Evaporator
Suction Line
Drier
Capillary
Compressor
Liquid Line
Condenser
Discharge Line
Vapor-High Pressure
Liquid-High Pressure
Vapor+Liquid-Low Pressure
Vapor-Low Pressure
Oil

Complete Basic Refrigeration System

Refrigeration Cycle


Evaporator
Suction Line
Drier
Capillary
Compressor
Liquid Line
Condenser
Discharge Line
Vapor-High Pressure
Liquid-High Pressure
Vapor+Liquid-Low Pressure
Vapor-Low Pressure
Oil

BASIC MECHANICAL REFRIGERATION
UNIT I

ASSIGNMENT SHEET #1--DRAW A BASIC REFRIGERATION SYSTEM

Draw a complete basic refrigeration system, identify the components, and show the direction of refrigerant flow.

BASIC MECHANICAL REFRIGERATION
UNIT I

JOB SHEET #1--ASSEMBLE A BASIC REFRIGERATION SYSTEM

I. Tools and materials

A. Tools

1. Tape measure
2. Flare nut wrenches
3. Swage punch
4. Ball peen hammer
5. Outside calipers
6. Flaring tool and block
7. Tubing benders
8. Torch
9. Tubing cutter

B. Materials

1. Compressor
2. Condenser
3. Evaporator
4. Metering device
5. Copper tubing
6. Flare nuts
7. Solder
8. Sand cloth
9. Flux

II. Procedure

A. Position components

JOB SHEET #1

B. Construct liquid line

1. Measure length and diameter of liquid line
2. Cut from stock
3. Ream both ends
4. Flare one end if needed
5. Place flare nuts on tubing
6. Flare other end if needed
7. Swage ends if needed
8. Bend tubing to fit system if needed

   (NOTE: All bends should be made with bender.)

C. Make suction line

1. Measure length and diameter of suction line
2. Cut from stock
3. Ream both ends
4. Flare one end if needed
5. Place flare nuts on tubing
6. Flare other end if needed
7. Swage ends if needed
8. Bend tubing to fit system if needed

   (NOTE: All bends should be made with bender.)

D. Make discharge line

(NOTE: Discharge line may be supplied as part of the condensing unit. If so, this step may be eliminated.)

1. Measure length and diameter of discharge line
2. Cut from stock
3. Ream both ends

JOB SHEET #1

4. Flare one end if needed
5. Place flare nuts on tubing
6. Flare other end if needed
7. Swage ends if needed
8. Bend tubing to fit system if needed

   (NOTE: All bends should be made with bender.)

E. Solder swage joints

(NOTE: Instructor will designate type of solder to be used.)

F. Clean solder joints

G. Connect liquid line

1. Outlet of condenser
2. Inlet of metering device

H. Connect suction line

1. Outlet of evaporator
2. Suction side of compressor

I. Connect discharge line

(NOTE: If discharge line is factory installed this step will be eliminated.)

1. Discharge of compressor
2. Inlet of condenser

J. Have instructor check your work

K. Do not disassemble this system; it will be used in the next unit

BASIC MECHANICAL REFRIGERATION
UNIT I

TEST

1. Match the terms on the right to the correct definition.

______a. Any device that meters or regulates the flow of liquid refrigerant to an evaporator and also divides the high from the low pressure side of the system

______b. Part of a refrigeration system which receives hot, high pressure refrigerant vapor from the compressor and removes heat from the refrigerant until it returns to a liquid state

______c. State of refrigerant that has absorbed a maximum amount of heat

______d. Compressor which uses vanes, eccentric mechanisms, or other rotating devices to provide pumping action

______e. The refrigerant flows through a series of coils formed to make the shelves on which products are stored

______f. Compressor in which the driving motor is sealed in the same welded dome that contains the compressor

______g. Lines required to carry the refrigerant liquid and vapor between the system components

______h. Compressor in which the driving motor is sealed in the same bolted housing that contains the compressor

______i. Condenser which is constructed by placing one tube inside a second tube

______j. Refrigerant control usually consisting of a predetermined length of tubing having a small inside diameter

1. Automatic expansion valve
2. Natural convection condenser
3. Refrigerant lines
4. Tube-within-a-tube condenser
5. Refrigerant
6. Evaporative condenser
7. Vapor state
8. Capillary tube
9. Liquid state
10. Compressor
11. Fin-type evaporator
12. Hermetic compressor
13. Reciprocal compressor
14. Shell-type evaporator
15. Condenser
16. Rotary compressor

______k. State of refrigerant that can absorb an additional amount of heat

______l. Compressor which uses a piston and cylinder mechanism to provide pumping action

______m. The evaporator coils are mounted in the walls of the freezer compartment which provides a larger cooling surface

______n. A condenser which transfers heat to the surrounding air through the use of a fan or blower

______o. A pressure controlled metering device which operates in response to evaporator pressure

______p. A substance used in refrigerating mechanisms to absorb heat in the evaporator

______q. These evaporators have fins attached to the tubing which gives a larger cooling surface

______r. Compressor in which the crankshaft extends through the crankcase and is driven by an outside motor

______s. Part of a refrigerating mechanism in which the refrigerant vaporizes and absorbs heat

______t. Pump of a refrigerating mechanism which draws a vacuum or low pressure on the cooling portion of the refrigerant cycle and compresses the vaporized refrigerant into the high pressure side of the system

______u. Hot vaporized refrigerant is fed into the top of the shell and comes into contact with the cool water tubes and condenses the refrigerant

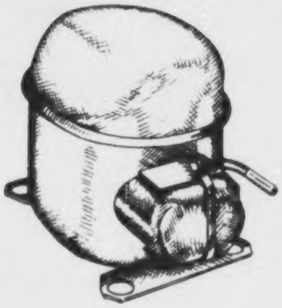
______v. Condenser which transfers heat to the surrounding air by means of natural air flow

______w. A metering device operated by temperature and pressure

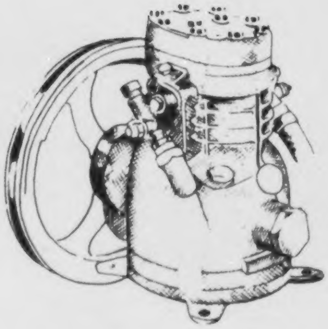
______x. A device which uses open spray or spilled water to cool a condenser

17. Forced convection condenser
18. Shelf-type evaporator
19. Shell and tube condenser
20. Semi-hermetic compressor
21. Metering device
22. Open compressor
23. Thermostatic expansion valve
24. Evaporator

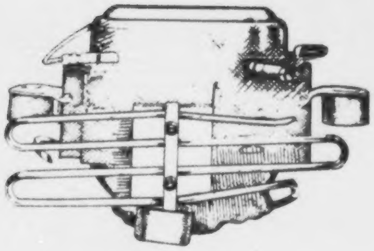
2. Identify the types of compressors.



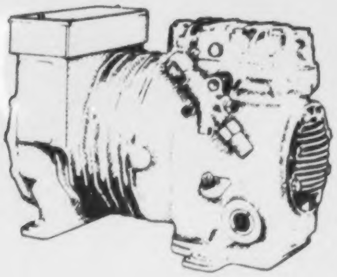
a. ______________________



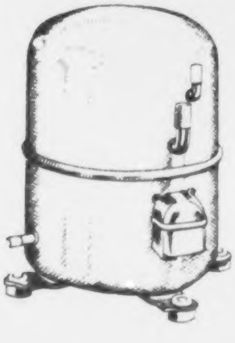
b. ______________________



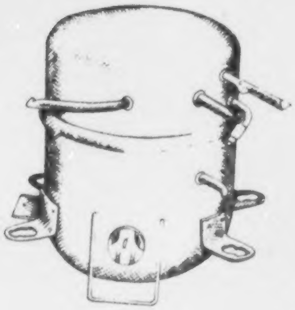
c. ______________________



d. ______________________

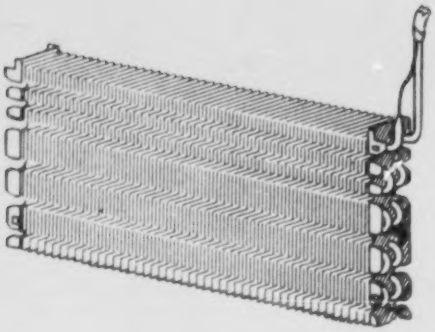


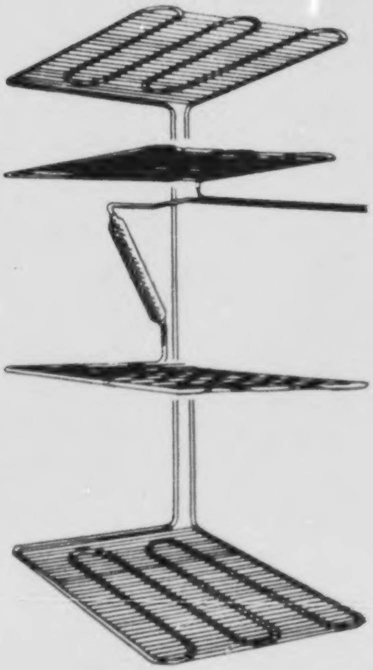
e. ______________________



f. ______________________

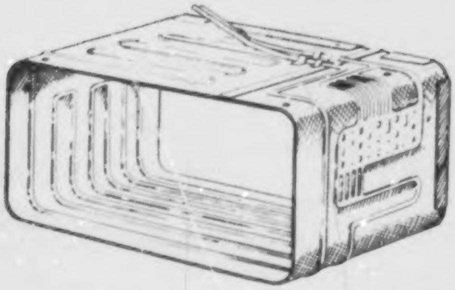
3. Identify the types of evaporators.





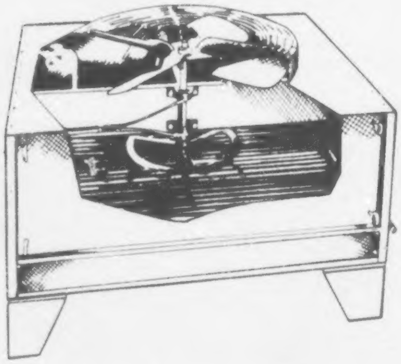
a. ______________________

b. ______________________

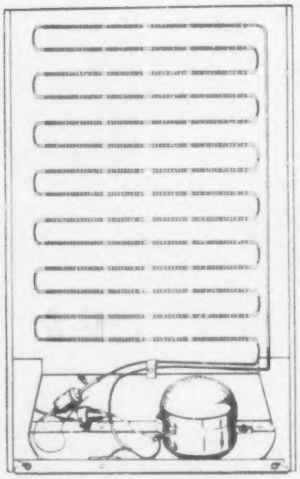


c. ______________________

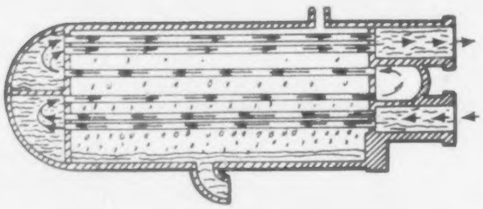
4. Identify the types of condensers.



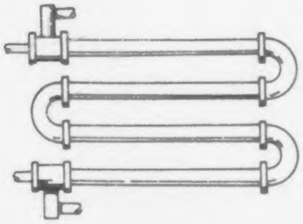
a.____________________



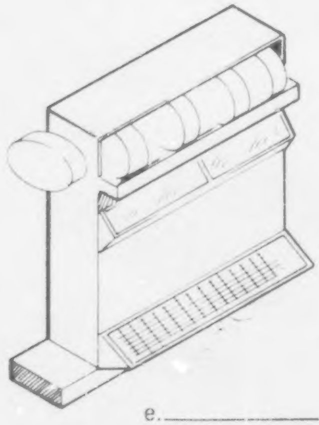
b.____________________



c.____________________



d.____________________



e.____________________

5. Select the types of metering devices commonly in use by placing an "X" in the blank.

______a. Low side float

______b. Capillary tube

______c. Thermostatic expansion valve

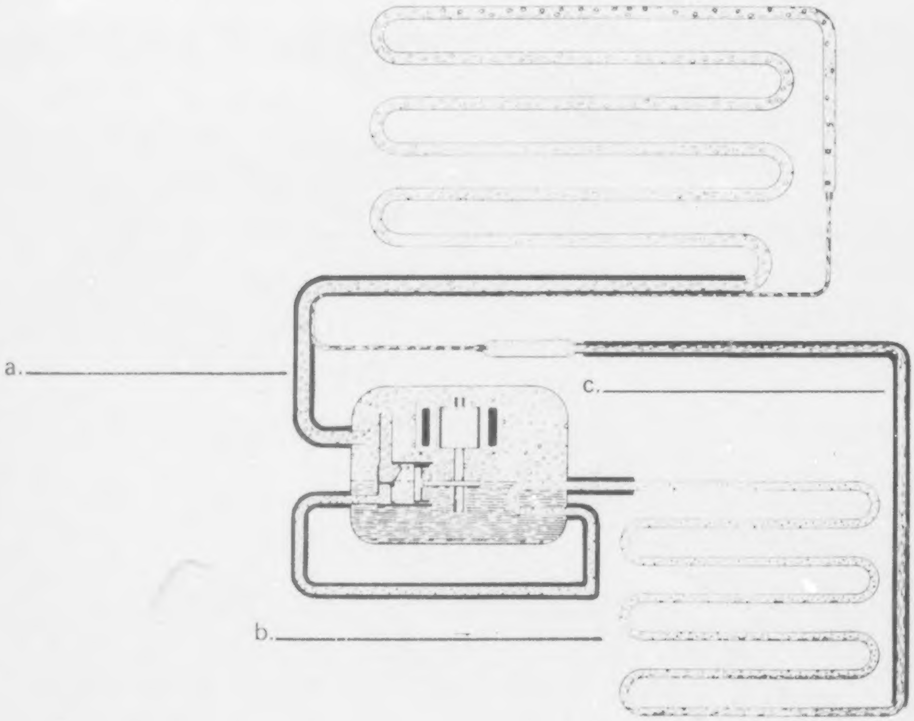
______d. Automatic expansion valve

______e. High side float

______f. Orifice

______g. Hand valve

6. Identify all connecting refrigerant lines.



7. Select the state of the refrigerant from the following list by placing "liquid" or "vapor" in the correct blanks.

___________a. Discharge line

___________b. Top of condenser

___________c. Bottom of condenser

___________d. Liquid line

___________e. Inlet of evaporator

___________f. Outlet of evaporator

___________g. Suction line

___________h. Compressor dome

8. Demonstrate the ability to:

a. Draw a basic refrigeration system

b. Assemble a basic refrigeration system

(NOTE: If these activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

BASIC MECHANICAL REFRIGERATION
UNIT I

ANSWERS TO TEST

1. a. 21
   b. 15
   c. 7
   d. 16
   e. 18
   f. 12
   g. 3
   h. 20
   i. 4
   j. 8
   k. 9
   l. 13
   m. 14
   n. 17
   o. 1
   p. 5
   q. 11
   r. 22
   s. 24
   t. 10
   u. 19
   v. 2
   w. 23
   x. 6

2. a. Reciprocal--Hermetic
   b. Reciprocal--Open
   c. Rotary
   d. Reciprocal--Semi-hermetic
   e. Reciprocal--Hermetic
   f. Rotary

3. a. Fin-type evaporator
   b. Shelf-type evaporator
   c. Shell-type evaporator

4. a. Forced convection (blower)
   b. Natural convection (static)
   c. Shell and tube
   d. Tube-within-a-tube
   e. Evaporative

5. b, c, d

6. a. Suction line
   b. Discharge line
   c. Liquid line

7. a. Vapor
   b. Vapor
   c. Liquid
   d. Liquid
   e. Liquid
   f. Vapor
   g. Vapor
   h. Vapor

8. Performance skills evaluated to the satisfaction of the instructor

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with refrigerant system accessories to the correct definitions or descriptions. He should also be able to identify the seven common accessories and their location, select the purpose of each accessory, and describe the types of service valves. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with refrigerant system accessories to the correct definitions or descriptions.
2. Identify refrigerant system accessories.
3. Select the purposes of each refrigerant system accessory.
4. Distinguish between factors in selecting a liquid line filter-drier and a suction line filter-drier.
5. Describe the types of service valves.
6. Locate and identify the refrigerant system accessories.
7. Demonstrate the ability to:
    a. Install a filter-drier with flare fittings.
    b. Install a filter-drier with sweat fittings.
    c. Install a capillary tube into a filter-drier.
    d. Install a liquid indicator with flare fittings.
    e. Use a stem type service valve.
    f. Install a line tap service valve.
    g. Install an access core type service valve.

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss the procedures outlined in the job sheets.

  G. Show the students the actual components on refrigeration systems.

  H. Locate old components and make cutaways.

  I. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Liquid Line Filter-Driers

    2. TM 2--Suction Line Filter-Driers

3. TM 3--Liquid Indicators and Moisture Indicators
4. TM 4--Receivers
5. TM 5--Service Valves
6. TM 6--Suction Line Accumulator and Vibration Eliminator
7. TM 7--Three Positions of the Stem Type Service Valve
8. TM 8--Access Valve Core Remover and Replacer
9. TM 9--Refrigerant System Accessories

D. Job sheets

1. Job Sheet #1--Install a Filter-Drier with Flare Fittings
2. Job Sheet #2--Install a Filter-Drier with Sweat Fittings
3. Job Sheet #3--Install a Capillary Tube into a Filter-Drier
4. Job Sheet #4--Install a Liquid Indicator with Flare Fittings
5. Job Sheet #5--Use a Stem Type Service Valve
6. Job Sheet #6--Install a Line Tap Service Valve
7. Job Sheet #7--Install an Access Core Type Service Valve

E. Test

F. Answers to test

II. References:

A. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Co., 1975.

B. *Suction Line Filter-Driers - Bulletin 40-15.* St. Louis, Missouri: Sporlan Valve Co., August 1974.

C. *Moisture and Liquid Indicator - Bulletin 70-10.* St. Louis, Missouri: Sporlan Valve Co., November 1972.

D. *Suction Filter - Bulletin 80-10.* St. Louis, Missouri: Sporlan Valve Co., October 1973.

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

INFORMATION SHEET

I. Terms and definitions or descriptions

A. Absorb--Ability of a substance to take up another substance

B. Adsorb--Ability of a substance to hold another substance on its surface without causing a chemical change

C. Desiccant--Chemical substance in a filter-drier that either adsorbs or absorbs contaminants

D. Drier--Device in refrigeration system which contains dessicant for the removal of moisture from the refrigerant, usually in the liquid line

(NOTE: These driers are generally directional which will allow the refrigerant to flow in one direction, but some small capacity driers are nondirectional.)

E. Front seat--Turning the stem of a stem type valve clockwise until the valve stem stops

(CAUTION: Never front seat the discharge service valve when the compressor is running.)

F. Back seat--Turning the stem of a stem type valve counterclockwise until the valve stem stops

(NOTE: This is the position the valve is in for normal operation.)

G. Cracked--Turning the stem of a stem type valve clockwise one-half to one full turn from a back seated position

(NOTE: This is the position normally used when servicing the refrigeration system.)

H. King valve (receiver service valve)--Stem type valve located at the outlet of the receiver

I. Liquid line valve--Three-way stem type service valve located in the liquid line and used for pump down or servicing

J. Pump down--Front seating the king valve or liquid line valve to capture the refrigerant in the high side

INFORMATION SHEET

K. Pressure stub (process tube)--Short piece of tubing attached to the refrigeration system for the purpose of pressure readings

(NOTE: These are sometimes called charging stubs.)

L. Refrigerant filter--Device for removing foreign particles from the refrigerant

(NOTE: This device is usually an integral part of the drier.)

II. Refrigerant system accessories

A. Liquid line filter-driers (Transparency 1)

1. Flare

2. Sweat

(NOTE: There are two types of sweat filter-driers. One is used primarily on central air-conditioning units and one is used on domestic refrigerators.)

B. Suction line filter-driers (Transparency 2)

1. Flare

2. Sweat

C. Liquid indicators (Transparency 3)

1. Flare

2. Sweat

(NOTE: There are different designs of the sweat liquid indicator, and they are commonly referred to as sight glasses.)

D. Moisture indicators

(NOTE: These are an integral part of some liquid indicators.)

E. Receivers (Transparency 4)

1. With a king or receiver service valve

2. Without a king or receiver service valve

F. Service valves (Transparency 5)

1. Stem type

INFORMATION SHEET

2. Access core type

   (NOTE: These valves are commonly called Schrader valves.)

3. Line tap

G. Suction line accumulator

H. Vibration eliminator (Transparency 6)

(NOTE: A vibration eliminator is always installed in the refrigerant line parallel to the crankshaft.)

III. Purposes of refrigerant system accessories

A. Liquid line filter-drier

1. Adsorbs and/or absorbs moisture
2. Catches foreign matter
3. Adsorbs acids

B. Suction line filter-drier

1. Adsorbs acid
2. Aids in catching foreign matter and sludge

C. Liquid indicator

1. Provides an easy method for checking amount of refrigerant charge

   (NOTE: Refrigerant charge is checked by checking for a solid column of liquid refrigerant in the glass. Vapor bubbles in the refrigerant may indicate a shortage of refrigerant.)

2. Provides a convenient holder for the moisture indicator

D. Moisture indicators--Change in color will indicate that there is moisture in the refrigeration system

(NOTE: Different manufacturers use chemicals that will change different colors to indicate a "wet" or "dry" condition.)

INFORMATION SHEET

E. Receiver

  1. Storage tank for liquid refrigerant
  2. Insures that ample liquid refrigerant will be available
  3. Not used on capillary tube systems

F. Service valves

  1. A port for connecting the refrigeration gauge set to the system
  2. Used when checking system pressures
  3. Used when pressurizing the system
  4. Used when evacuating the system
  5. Used when charging the system
  6. Used when pumping down the system
  7. Used for system isolation

G. Suction line accumulator

  1. Holds excess liquid refrigerant from the evaporator
  2. Aids in preventing liquid refrigerant from enter [illegible] suction side of the compressor

H. Vibration eliminator

  1. Absorbs refrigerant line vibration
  2. Aids in preventing the lines from becoming loose or breaking

IV. Factors in selecting a filter-drier

A. Liquid line filter-driers

  1. Moisture removal capacity
  2. Amount of refrigerant flow
  3. Filter area
  4. Type of line connection
  5. Size of line connection

INFORMATION SHEET

B. Suction line filter-driers

  1. Type of refrigerant in system

  2. Compressor size in horsepower

  3. Size of suction line

V. Service valves

A. Stem type

  1. Permanent part of the system

  2. Three valve positions (Transparency 7)

    a. Back seated for normal operation

    b. Cracked for checking pressures and servicing

    c. Front seated for isolating the compressor and pump down

    (CAUTION: Never front seat the discharge service valve when the compressor is running.)

B. Access core type

  1. No valve stem for shut-off

  2. May be installed either permanently or temporarily

    a. Factory installation is permanent

    b. Field installation may be either

  3. Pressure is present whenever the valve core is depressed

  (CAUTION: When removing a gauge hose from a core type valve use a cloth and wear safety glasses to protect from refrigerant burn. The cloth will also help to prevent an oil spot.)

  4. When evacuating or charging, a special tool should be used to remove the core from the valve (Transparency 8)

  5. Cap serves as the primary valve seal

  (NOTE: Always replace the cap on service valves.)

INFORMATION SHEET

C. Line tap

1. Should be used for temporary installation only

2. Install on pressure stub for ease in removal

3. May have a valve stem for closing valve before removal of gauge hose

VI. Location of refrigerant system accessories (Transparency 9)

A. Liquid line filter-drier

B. Suction line filter-drier

C. Liquid indicator

D. Moisture indicator

E. Receiver

F. Service valves

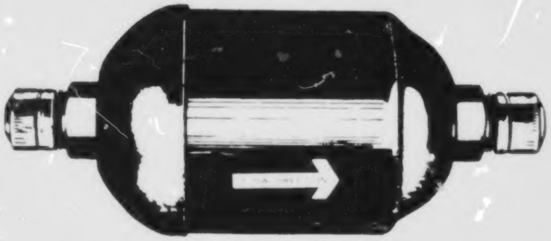
(NOTE: Equipment manufacturers may locate their service valves in different areas, but they should always be close to the compressor.)

G. Suction line accumulator

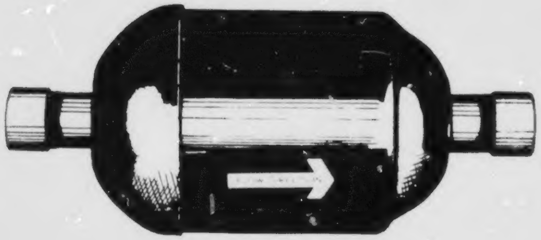
H. Vibration eliminator

Liquid Line Filter-Driers

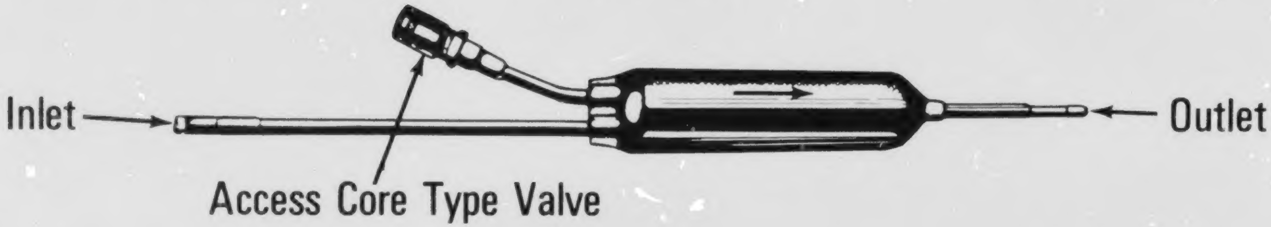
Flare



Sweat

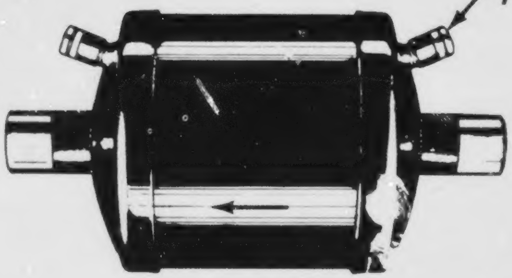


Sweat

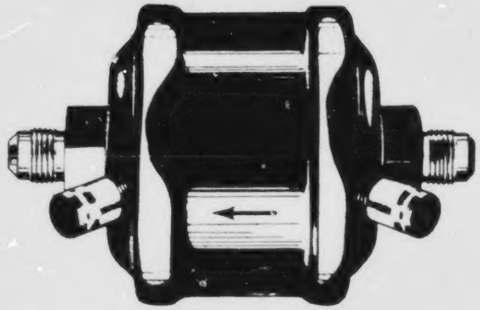

Inlet
Outlet
Access Core Type Valve

Suction Line Filter-Driers

Sweat

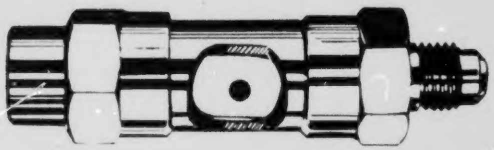

Access Core
Type Valve

Flare

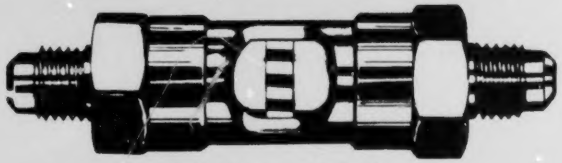


Liquid Indicators and Moisture Indicators

Moisture Indicators
Flare Type Liquid Indicators

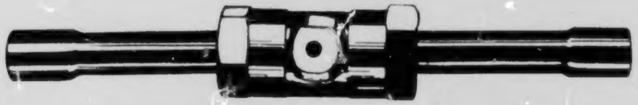


Female to Male



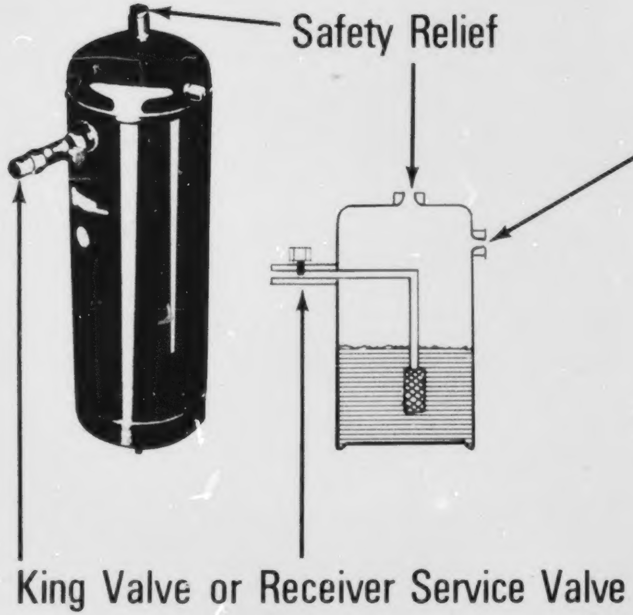
Male to Male

Sweat Type Liquid Indicators

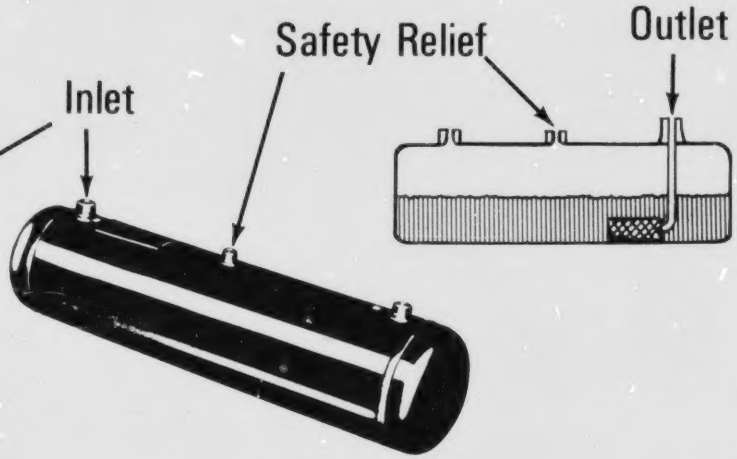


Receivers

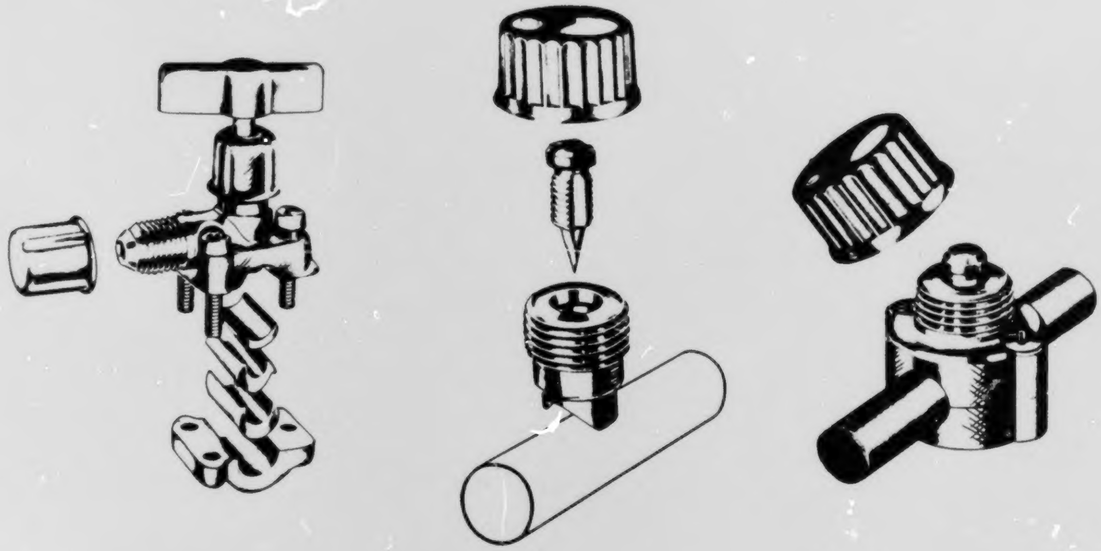
With a Valve


Safety Relief
King Valve or Receiver Service Valve

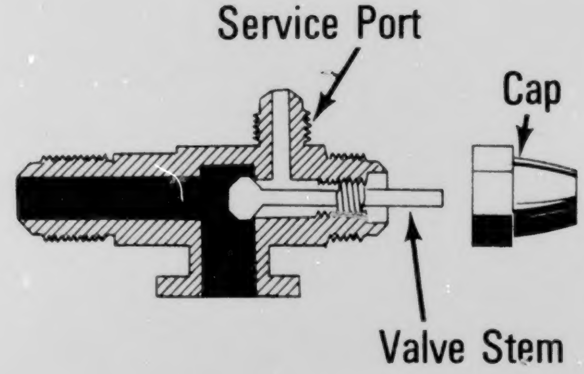
Without a King or Receiver Service Valve


Safety Relief
Outlet
Inlet

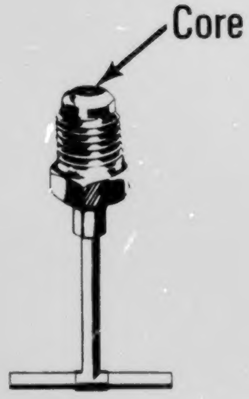
Service Valves



Line Taps


Service Port
Cap
Valve Stem

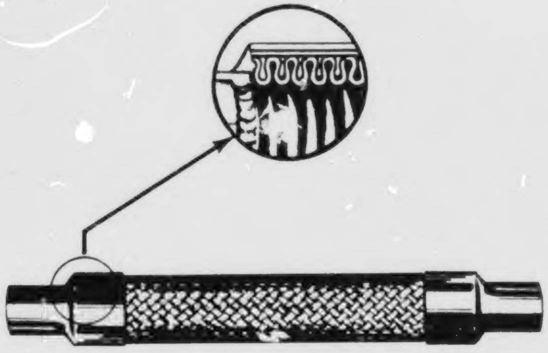
Stem Type



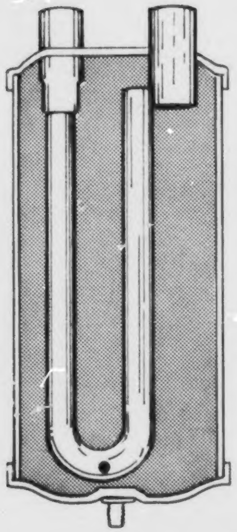
Core Type

Suction Line Accumulator and Vibration Eliminator

Vibration Eliminator

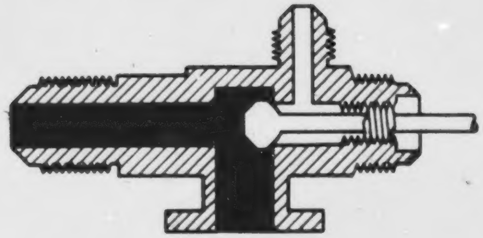


Suction Line Accumulator

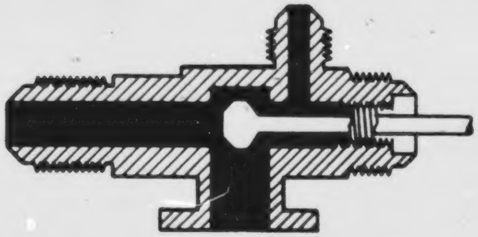


Three Positions of the Stem Type Service Valve

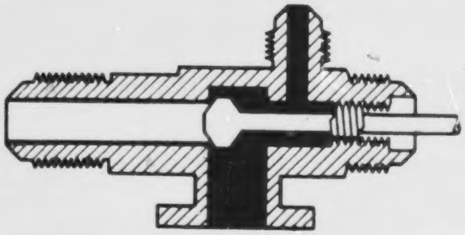
Back Seated



Cracked

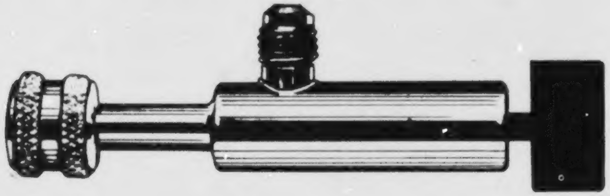


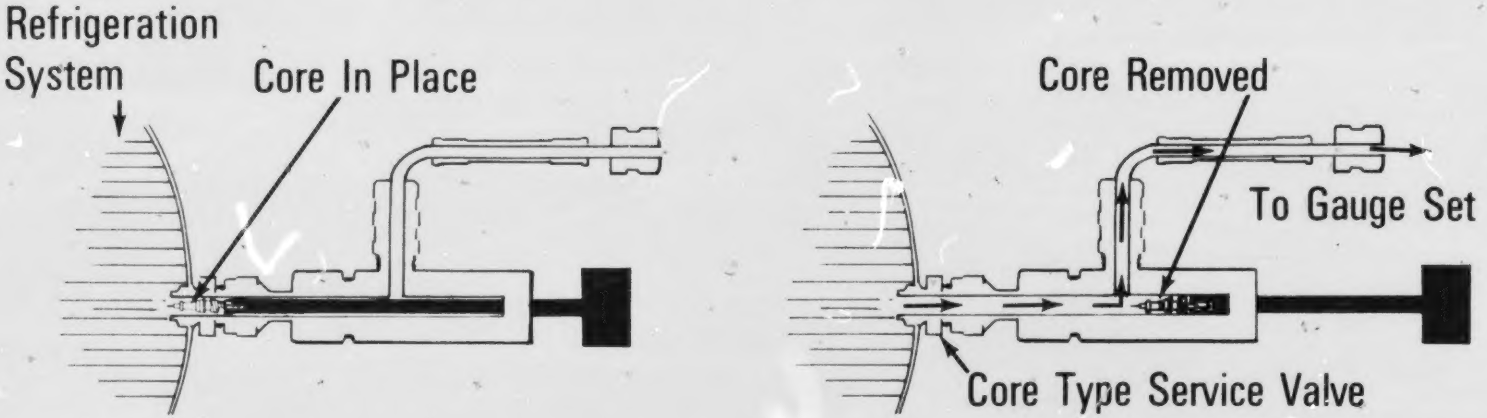
Front Seated



Access Valve Core Remover and Replacer

Access Valve Core Remover and Replacer



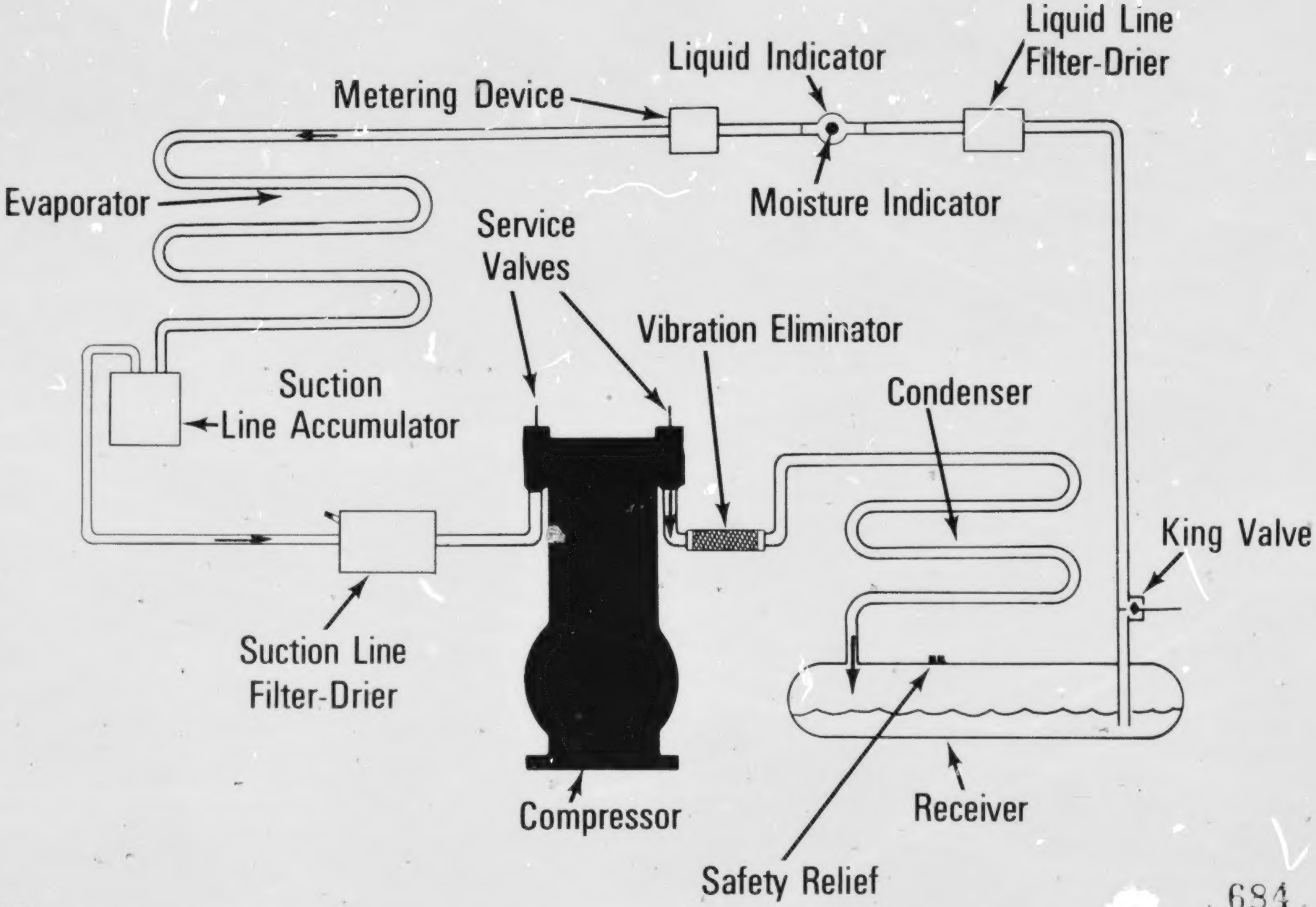

Refrigeration System
Core In Place
Core Removed
To Gauge Set
Core Type Service Valve

Provides for Removal and Reinstallation of the Core without Refrigerant Loss

TM - 8

ACR I - 67-F

Refrigerant System Accessories


Liquid Line Filter-Drier
Liquid Indicator
Metering Device
Evaporator
Moisture Indicator
Service Valves
Vibration Eliminator
Suction Line Accumulator
Condenser
King Valve
Suction Line Filter-Drier
Compressor
Receiver
Safety Relief

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

JOB SHEET #1--INSTALL A FILTER-DRIER WITH FLARE FITTINGS

I. Tools and materials

- A. Tubing cutter
- B. Flaring block
- C. Flaring tool
- D. Flare nut wrench
- E. Open end wrench
- F. Safety glasses
- G. Refrigeration gauge set
- H. Refrigeration ratchet
- I. Oil can
- J. Refrigeration system
- K. Filter-drier with male flare fittings
- L. Two flare nuts

II. Procedure

- A. Put on safety glasses
- B. Install refrigeration gauge set
- C. If refrigeration system is under pressure, slowly release pressure or pump down
- D. Cut liquid line close to the inlet of the metering device
- E. Remove a section of liquid line the length of the filter-drier
- F. Place flare nuts on tubing
- G. Flare tubing

JOB SHEET #1

H. Remove the protective cap from one end of the filter-drier

(NOTE: Remove only one cap at a time but do not remove until ready to install the filter-drier because the dessicant will become saturated with moisture from the air if the filter-drier is left open.)

I. If using a directional filter-drier, be sure to install it with refrigerant flow toward the metering device

(NOTE: The direction of refrigerant flow is indicated on a filter-drier with an arrow or with the words "in" and "out".)

J. Finger tighten flare nut

K. Remove protective cap from other end of filter-drier

L. Finger tighten flare nut

M. Place flare nut wrench on flare nut

N. Place open-end wrench on adjacent hexagon part of the filter-driers male flare fitting

O. Tighten both flare nuts

(NOTE: At this point the instructor may request a leak check.)

P. Have instructor inspect

Q. Clean up and put away tools

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

JOB SHEET #2--INSTALL A FILTER-DRIER WITH SWEAT FITTINGS

I. Tools and materials

  A. Tubing cutter

  B. Torch

  C. Striker

  D. Colored safety glasses

  E. Safety glasses

  F. Refrigeration ratchet

  G. Refrigeration gauge set

  H. Refrigeration system

  I. Filter-drier with sweat fittings

  J. Silver alloy brazing rod

  K. Sand cloth

  L. Silver brazing flux

  M. Damp shop towel

  N. Nitrogen cylinder

II. Procedure

  A. Put on safety glasses

  B. Install refrigeration gauge set

  C. If refrigeration system is under pressure, slowly release pressure

  D. Use the sand cloth and polish the liquid line prior to cutting

  E. Cut liquid line close to the inlet of the metering device

  F. Check for proper direction of refrigerant flow

  G. Remove a section of liquid line the length of the filter-drier

  H. Repolish ends after cutting

JOB SHEET #2

I. Apply flux to the polished ends

J. Remove the protective cap from one end of the filter-drier

(NOTE: On some small filter-driers used for domestic refrigeration, the ends must be cut-off with a tubing cutter.)

K. Insert liquid line into one end of filter-drier

L. Twist the filter-drier while inserting the line to insure sufficient coating of flux

M. Remove protective cap from the other end of the filter-drier

N. Insert the other end of the liquid line

O. Twist the filter-drier while inserting the line

(NOTE: Special precautions are necessary when installing a capillary tube directly into a filter-drier. This procedure is covered in detail on a separate job sheet.)

P. If using a line-drier with an access core type valve, remove the core to prevent the heat from damaging it

Q. Attach nitrogen cylinder to refrigeration gauge set

R. Adjust nitrogen regulator for 2 p.s.i.g.

S. Allow nitrogen to circulate through the system

T. Put on colored safety glasses

U. Light and adjust torch

V. Apply heat to joint; direct heat away from joint

W. Apply silver brazing alloy

(CAUTION: Cadmium free silver brazing alloy is the recommended alloy to use.)

X. Silver braze the other end

Y. Turn off the torch

Z. Clean the flux from both joints with a damp cloth before the joint cools

AA. Check both joints to be sure all of the flux is removed

BB. Have instructor inspect

CC. Clean up and put tools away

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

JOB SHEET #3--INSTALL A CAPILLARY TUBE INTO A FILTER-DRIER

I. Tools and materials

   A. Tubing cutter

   B. Flat file or taper file

   C. Pliers

   D. Torch

   E. Striker

   F. Colored safety glasses

   G. Orifice drill set

   H. Safety glasses

   I. Refrigeration gauge set

   J. Refrigeration system

   K. Filter-drier (domestic refrigeration type)

   L. Silver alloy brazing rod

   M. Sand cloth

   N. Silver brazing flux

   O. Damp shop towel

II. Procedure

   A. Put on safety glasses

   B. Install refrigeration gauge set

   C. If refrigeration system is under pressure, slowly release pressure

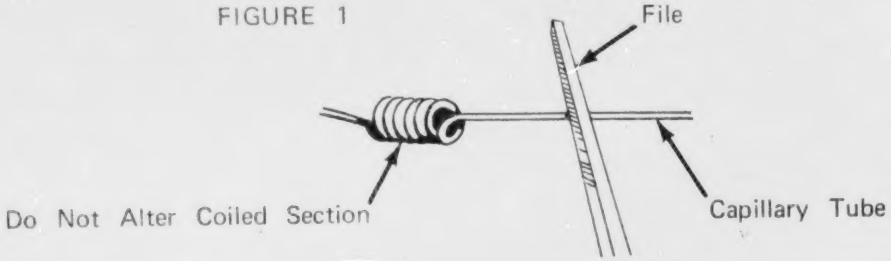
   D. Cut liquid line close to the inlet of the metering device

JOB SHEET #3

E. Score the capillary tube with a file and break it off square (Figure 1)

(NOTE: Capillary tubing should not be cut with a tubing cutter as this will reduce the inside diameter of the capillary tubing.)

FIGURE 1

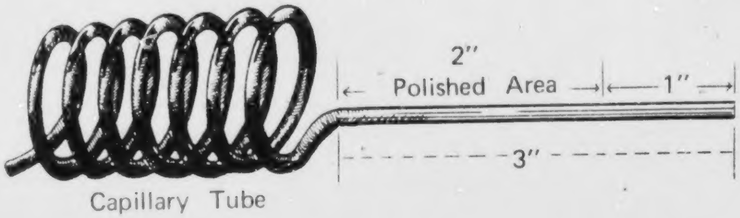

File
Do Not Alter Coiled Section
Capillary Tube

F. Straighten the end of the capillary tube; three inches should be sufficient

G. Ream the end of the capillary tube with proper orifice file

H. One inch in from end of capillary tube, polish a two inch section (Figure 2)

FIGURE 2


2"
Polished Area
1"
3"
Capillary Tube

(NOTE: If one inch of the capillary tube is left uncleaned, the silver alloy will have less tendency to flow down the tube and restrict the end.)

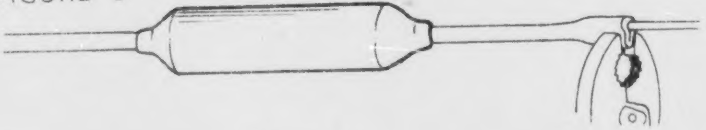
I. If using a filter-drier with an access core type valve, remove the core to prevent the heat from damaging it

JOB SHEET #3

J. Insert capillary tube into outlet end of filter-drier (Figure 3)

(NOTE: Do not kink the capillary tube.)

FIGURE 3



K. Crimp tubing if necessary

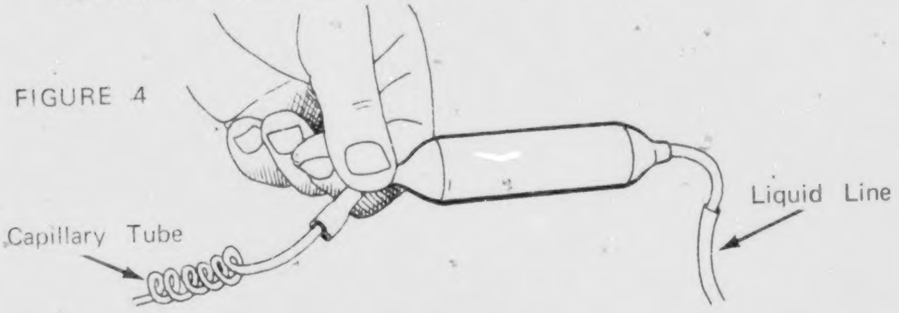
(NOTE: It may be better to place a solid piece of copper wire or a small drill bit into the end of the drier while crimping to prevent damage to the capillary tube.)

L. Apply flux to joint

M. Tilt outlet end of filter-drier down (Figure 4)

(NOTE: This will help to prevent the silver alloy from going down the capillary tube and causing a restriction.)

FIGURE 4



N. Apply heat to joint away from drier

O. Apply silver alloy

P. Remove heat as soon as alloy flows around the joint

Q. Turn off torch

R. Clean flux from joint with a damp cloth

S. Recheck to be sure that all of the flux has been removed

T. Have instructor inspect

U. Clean up and put away tools

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

JOB SHEET #4--INSTALL A LIQUID INDICATOR WITH FLARE FITTINGS

I. Tools and materials

- A. Tubing cutter
- B. Flaring tool
- C. Flaring block
- D. Flare nut wrench
- E. Open end wrench
- F. Safety glasses
- G. Oil can
- H. Refrigeration gauge set
- I. Refrigeration system with an expansion valve
- J. Liquid indicator
- K. Flare nuts

II. Procedure

- A. Put on safety glasses
- B. Install refrigeration gauge set
- C. If refrigeration system is under pressure, slowly release pressure or pump down
- D. Cut liquid line between the outlet of the filter-drier and the inlet of the metering device
- E. Place flare nuts on tubing
- F. Flare the tubing
- G. Lightly oil fittings
- H. Install liquid indicator
- I. Tighten both flare nuts finger tight

JOB SHEET #4

J. Hold body of liquid indicator with open end wrench

K. Tighten flare nuts with the flare nut wrench

L. Have instructor inspect

M. Clean up and put away tools

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

JOB SHEET #5--USE A STEM TYPE SERVICE VALVE

I. Tools and materials

A. Refrigeration ratchet

B. Refrigeration gauge set

C. Open end wrench

D. Safety glasses

E. Oil can

F. Refrigeration system with stem type service valves

G. Clean shop towel

II. Procedure

A. Put on safety glasses

B. Remove valve stem covers

C. Remove service port caps

(NOTE: If a pressure switch capillary tube is connected to the service port, back seat the valve stem before removing the flare nut.)

D. Clean around gauge ports

E. Attach gauge hoses

F. Check to be sure gauge manifold valves are closed to center port

G. Place two drops of oil on valve stems at the packing nut

H. Crack service valve stems

I. Purge hose at gauge manifold connection

J. Start system

K. Allow system pressures to stabilize

L. If high side gauge vibrates excessively, back seat the discharge service valve stem until vibration stops

JOB SHEET #5

M. Check pressure readings

N. Back seat service valves

O. Open refrigeration gauge set valves to release hose pressure

P. Remove gauge hoses

(NOTE: Gauge hoses should be plugged or placed on hose holder when not in use.)

Q. Replace service port caps and tighten

(NOTE: If pressure switches are connected to the valve service ports, the valve stems will have to be cracked during normal operation.)

R. Check valve stem packing nuts for leaks

S. If leak is indicated, tighten the packing nuts

T. Replace the valve stem caps

U. Clean up and put away tools

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

JOB SHEET #6--INSTALL A LINE TAP SERVICE VALVE

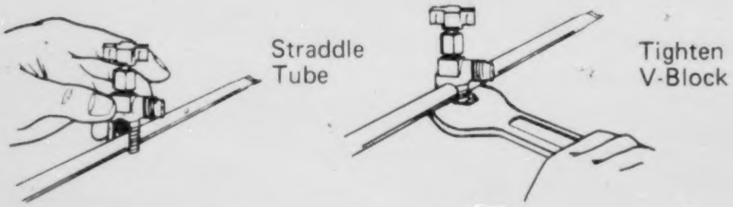
I. Tools and materials

- A. Open end wrench
- B. Phillips screwdriver
- C. Pinch-off tool
- D. Torch
- E. Striker
- F. Safety glasses
- G. Colored safety glasses
- H. Refrigeration system
- I. Line tap valve
- J. Sand cloth
- K. Sil-phos
- L. Dry clean shop towel
- M. Damp clean shop towel

II. Procedure

- A. Put on safety glasses
- B. Clean an area on the pressure stub where the valve will fit
- C. Place valve on pressure stub (Figure 1)

FIGURE 1



- D. Tighten valve onto the pressure stub
- E. Tighten gauge hose onto valve port

JOB SHEET #6

F. Check to be sure gauge manifold valves are closed

G. Pierce the pressure stub

H. Purge hose at gauge manifold connection

I. Start system

J. Check system pressures

K. Close line tap valves

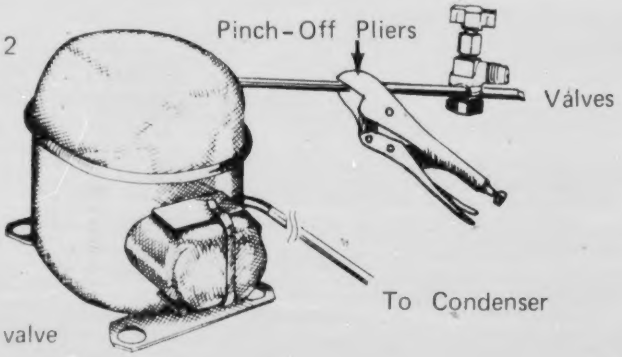
(NOTE: Some line taps are equipped with access core type valves, and cannot be closed manually prior to removing the hoses.)

L. Remove hoses from line taps

M. Place pinch-off tool on pressure stub (Figure 2)

(CAUTION: Be sure the line is completely sealed off before removing the valve.)

FIGURE 2



N. Remove line tap valve

O. Put on colored safety glasses

P. Light and adjust torch

Q. Braze the pierced opening

R. Turn off torch

S. Cool the pressure stub with damp cloth

T. Remove pinch-off tool

U. Check for leaks

V. Have instructor inspect

W. Clean up and put away tools

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

JOB SHEET #7--INSTALL AN ACCESS CORE TYPE SERVICE VALVE

I. Tools and materials

A. Valve core tool

B. Torch

C. Striker

D. Safety glasses

E. Access core type service valve

F. Silver alloy

G. Sand cloth

H. Silver brazing flux

I. Clean damp shop towel

II. Procedure

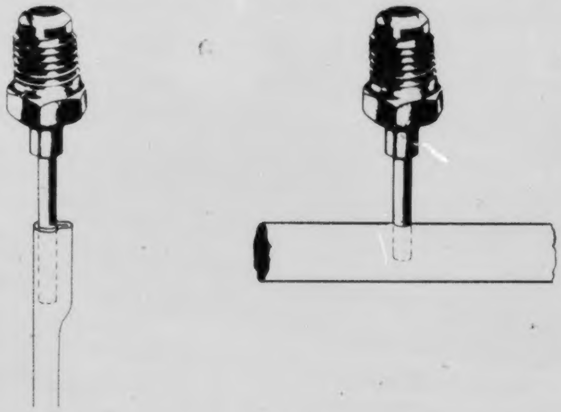
A. Put on safety glasses

B. Clean area on tubing where valve is to be placed

C. Remove the core from the valve

D. Place the valve on the tubing or in the pressure stub (Figure 1)

FIGURE 1



JOB SHEET #7

E. Apply flux to the joint

F. Light and adjust the torch

G. Apply heat to the joint

H. Apply the silver alloy

I. Remove heat as soon as the alloy flows completely around the joint

J. Turn off the torch

K. Clean the joint with a clean damp shop towel

(NOTE: Be careful that moisture does not enter the refrigeration system while cleaning and cooling the braze joint.)

L. Replace the core in the valve

(NOTE: If this is a line piercing valve, use the manufacturer's recommended procedure for piercing the line.)

M. Have the instructor inspect

N. Clean up and put away tools

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

TEST

1. Match the terms on the right to the correct definitions or descriptions.

_____a. Ability of a substance to take up another substance

_____b. Front seating the king valve or liquid line valve to capture the refrigerant in the high side

_____c. Turning the stem of a stem type valve counterclockwise until the valve stem stops

_____d. Ability of a substance to hold another substance on its surface without causing a chemical change

_____e. Turning the stem of a stem type valve clockwise until the valve stem stops

_____f. Short piece of tubing attached to the refrigeration system for the purpose of pressure readings

_____g. Chemical substance in a filter-drier that either adsorbs or absorbs contaminants

_____h. Turning the stem of a stem type valve clockwise one-half to one full turn from a back seated position

_____i. Stem type valve located at the outlet of the receiver

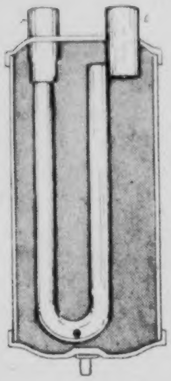
_____j. Device in refrigeration system which contains dessicant for the removal of moisture from the refrigerant, usually in the liquid line

_____k. Device for removing foreign particles from the refrigerant

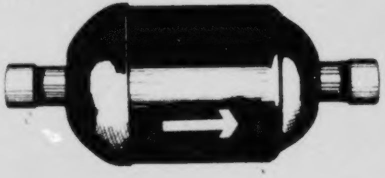
_____l. Three-way stem type service valve located in the liquid line and used for pump down or servicing

1. Pump down
2. Absorb
3. Back seat
4. Drier
5. King valve (receiver service valve)
6. Pressure stub (process tube)
7. Adsorb
8. Cracked
9. Desiccant
10. Front seat
11. Liquid line valve
12. Refrigerant filter

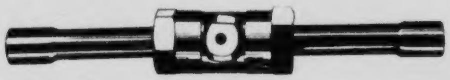
2. Identify the refrigerant system accessories.



a. ____________________



b. ____________________



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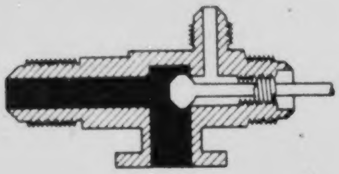
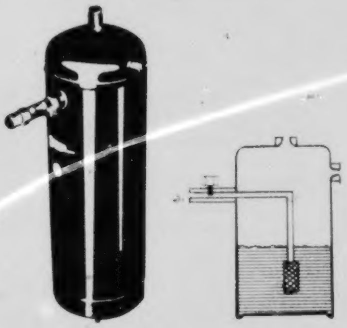
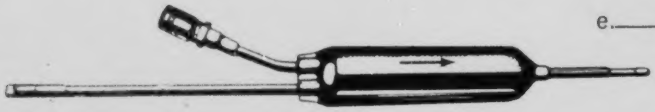


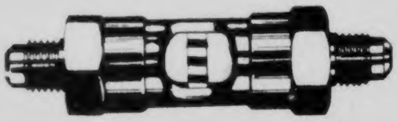
d. ____________________



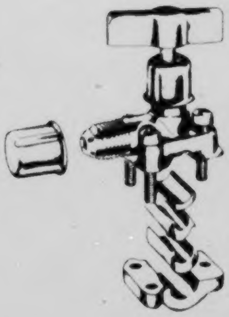
e. ____________________



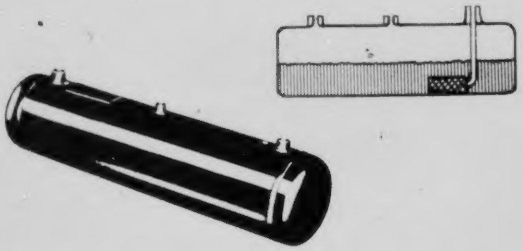
f. ____________________



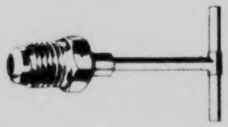
g. ____________________



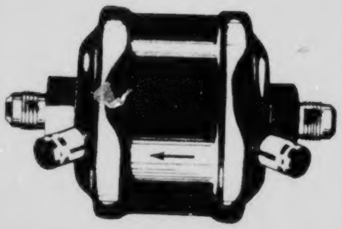
h. ____________________



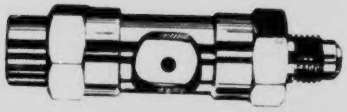
i. ____________________



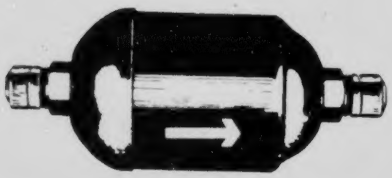
j. ____________________



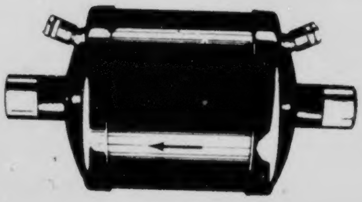
k. ______________________________



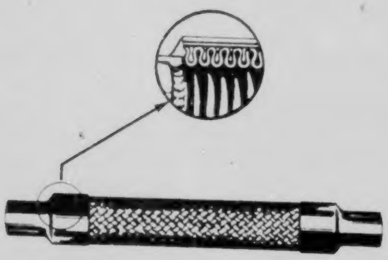
l. ______________________________



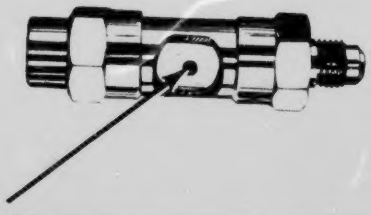
m. ______________________________



n. ______________________________



o. ______________________________



p. ______________________________

3. Select the purposes of each refrigerant system accessory by placing an "X" in the appropriate blank or blanks.

a. Receiver

______1) Storage tank for system contaminants

______2) Insures that ample liquid refrigerant will be available

______3) Used on capillary tube systems

______4) Two-way radio in a service truck

______5) Storage tank for liquid refrigerant

b. Suction line filter-drier

______1) Installed at inlet of metering device

______2) Adsorbs acid

______3) Aids in catching foreign matter and sludge

______4) Installed prior to a compressor burn out

c. Service valves

______1) Compressors internal valves

______2) Used when charging the system

______3) A port for connecting the refrigeration gauge set to the system

______4) Connections for the suction line accumulator

d. Vibration eliminator

______1) Absorbs refrigerant line vibration

______2) Condenser mounting springs

______3) Aids in preventing the lines from becoming loose or breaking

e. Liquid line filter-drier

______1) Absorbs refrigerant

______2) Adsorbs and/or absorbs moisture

______3) Filters the air bubbles in the refrigerant

______4) Catches foreign matter

______5) Adsorbs acids

f. Moisture indicator

______1) Separates the water from the refrigerant

______2) Change in color will indicate that there is moisture in the refrigeration system

______3) Indicates the amount of humidity that the refrigeration system is removing

g. Suction line accumulator

______1) Contains a desiccant for drying the refrigerant

______2) Holds excess liquid refrigerant from the evaporator

______3) Creates a suction on the liquid line

______4) Aids in preventing liquid refrigerant from entering the suction side of the compressor

h. Liquid indicator

______1) Provides a convenient holder for the moisture indicator

______2) Used only on capillary tube systems

______3) Provides an easy method for checking amount of refrigerant charge

4. Distinguish between liquid line filter-driers and suction line filter-driers by placing an "X" in front of the factors in selecting a liquid line filter-drier.

______a. Type of refrigerant in system

______b. Amount of refrigerant flow

______c. Filter area

______d. Compressor size in horsepower

______e. Size of suction line

______f. Type of line connection

______g. Size of line connection

______h. Moisture removal capacity

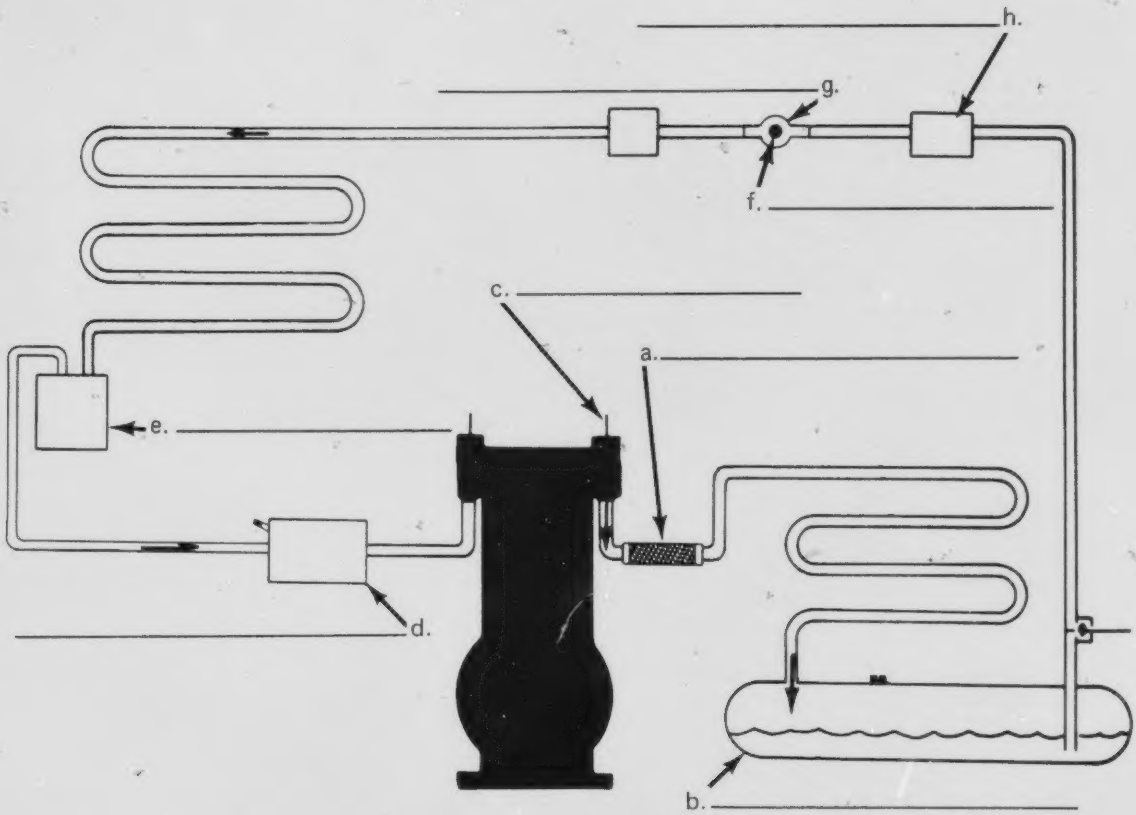
5. Describe the types of service valves.

   a. Stem type

   b. Access core type

   c. Line tap

6. Locate and identify the refrigerant system accessories.



7. Demonstrate the ability to:
   - a. Install a filter-drier with flare fittings.
   - b. Install a filter-drier with sweat fittings.
   - c. Install a capillary tube into a filter-drier.
   - d. Install a liquid indicator with flare fittings.
   - e. Use a stem type service valve.
   - f. Install a line tap service valve.
   - g. Install an access core type service valve.

   (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

3. a. 2, 5
   b. 2, 3
   c. 2, 3
   d. 1, 3
   e. 2, 4, 5
   f. 2
   g. 2, 4
   h. 1, 3

4. b, c, f, g, h

5. Description should include:
   a. Stem type
      1) Permanent part of the system
      2) Three valve positions
         a) Back seated for normal operation
         b) Cracked for checking pressures and servicing
         c) Front seated for isolating the compressor and pump down
   b. Access core type
      1) No valve stem for shut-off
      2) May be installed either permanently or temporarily
         a) Factory installation is permanent
         b) Field installation may be either
      3) Pressure is present whenever the valve core is depressed
      4) When evacuating or charging, a special tool should be used to remove the core from the valve
      5) Cap serves as the primary valve seal
   c. Line tap
      1) Should be used for temporary installation only
      2) Install on pressure stub for ease in removal
      3) May have a valve stem for closing valve before removal of gauge hose

REFRIGERANT SYSTEM ACCESSORIES
UNIT II

ANSWERS TO TEST

1. a. 2
   b. 1
   c. 3
   d. 7
   e. 10
   f. 6
   g. 9
   h. 8
   i. 5
   j. 4
   k. 12
   l. 11

2. a. Suction line accumulator
   b. Sweat type liquid line filter-drier
   c. Sweat type liquid indicator
   d. Stem type service valve
   e. Receiver with a king or receiver service valve
   f. Sweat type liquid line filter-drier
   g. Flare type liquid indicator
   h. Line tap service valve
   i. Receiver without a king or receiver service valve
   j. Access core type service valve
   k. Flare type suction line filter-drier
   l. Female to male flare liquid indicator
   m. Flare type liquid line filter-drier
   n. Sweat type suction line filter-drier
   o. Vibration eliminator
   p. Moisture indicator

6. a. Vibration eliminator
   b. Receiver
   c. Service valve
   d. Suction line filter-drier
   e. Suction line accumulator
   f. Moisture indicator
   g. Liquid indicator
   h. Liquid line filter-drier
7. Performance skills evaluated to the satisfaction of the instructor

REFRIGERANTS
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to match the types of refrigerants to their applications, name three methods of leak detection, list the safety rules for refrigerants, and compute temperature-pressure problems. The student should also be able to pressure check a refrigerator and an air conditioner. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with refrigerants to the correct definitions.
2. Match the common types of refrigerants to their chemical name.
3. Match the cylinder color codes to the types of refrigerants.
4. Match the types of refrigerants to their applications.
5. List seven desirable characteristics of a refrigerant.
6. Match sections of the temperature-pressure chart to the name.
7. Name three methods of leak detection.
8. List safety precautions for refrigerant handling.
9. Describe the procedure for obtaining refrigeration system pressures.
10. List three methods of determining what type of refrigerant is in a system.
11. Demonstrate the ability to:
    a. Compute temperature-pressure problems.
    b. Pressure check a domestic refrigerator.
    c. Pressure check an air conditioner.
    d. Pressure check a commercial refrigerator.
    e. Determine type of refrigerant used in a central air conditioner.

REFRIGERANTS
UNIT III

SUGGESTED ACTIVITIES

I. Instructor:

  A. Provide student with objective sheet.

  B. Provide student with information, assignment, and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information and assignment sheets.

  F. Demonstrate and discuss the procedures outlined in the job sheets.

  G. Demonstrate how to read an inaccessible data plate using a mirror.

  H. Give test.

II. Student:

  A. Read objective sheet.

  B. Study information sheet.

  C. Complete assignment and job sheets.

  D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Refrigerant Drums

    2. TM 2--Temperature-Pressure Chart

    3. TM 3--Temperature-Pressure Chart (Continued)

4. TM 4--Temperature-Pressure Chart (Continued)
5. TM 5--Leak Detection Using a Soap Solution
6. TM 6--Leak Detection Using a Halide Torch
7. TM 7--Leak Detection Using an Electronic Leak Detector
8. TM 8--Reading Gauges

D. Assignment sheets

1. Assignment Sheet #1--List Cylinder Color Code
2. Assignment Sheet #2--Compute Temperature-Pressure Problems

E. Answers to assignment sheets

F. Job sheets

1. Job Sheet #1--Pressure Check a Domestic Refrigerator
2. Job Sheet #2--Pressure Check an Air Conditioner
3. Job Sheet #3--Pressure Check a Commercial Refrigerator
4. Job Sheet #4--Determine Type of Refrigerant Used in a Central Air Conditioner

G. Test

H. Answers to test

II. References:

A. Downing, R. C. *Refrigerants and Service Pointers Manual.*, Wilmington, Delaware: Freon Products Division/Dupont DeNemours and Co., 1970.

B. Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox Co., 1968.

C. Schweitzer, Gerald, and Ebeling, A. *Basic Air Conditioning.* New York: Hayden Book Co., 1971.

REFRIGERANTS
UNIT III

INFORMATION SHEET

I. Terms and definitions

A. Refrigerant--Any substance which produces a refrigerating effect by its absorption of heat while evaporating

B. Fluorocarbon--Refrigerant compound containing one or more carbon atoms and fluorine

C. Halogen--Group of chemicals, of which the most active is fluorine

D. Halide refrigerants--Group of refrigerants containing halogen chemicals

(NOTE: Freon is a trade name for a group of halide refrigerants.)

E. R-11--Trichloromonofluoromethane, $CC1_3F$, a halide refrigerant

F. R-12--Dichlorodifluoromethane, $CC1_2F_2$, a halide refrigerant

(NOTE: This is used primarily in domestic refrigerators, freezers, automobile air conditioners, and some window air conditioners.)

G. R-22--Monochlorodifluoromethane, $CHClF_2$, a halide refrigerant

(NOTE: This is used for freezers and for window and central air conditioners.)

H. Azeotropic mixtures--Mixtures of halide refrigerants in order to make a single refrigerant

(NOTE: Common azeotropic mixtures are R-500 and R-502.)

I. R-717--Ammonia, NH_3, a nonhalide refrigerant

(NOTE: This is used for large industrial refrigeration and absorption type refrigeration and air conditioning.)

J. Refrigerant cylinder--Container in which refrigerant is purchased and dispensed

(NOTE: Cylinders are sometimes referred to as drums.)

K. Disposable refrigerant cylinder--Refrigerant container which cannot be refilled

INFORMATION SHEET

L. Ambient temperature--Temperature of air which surrounds an object on all sides

M. Refrigerant oil--Special dehydrated oil used in a refrigeration mechanism for lubrication and cooling

II. Common types of refrigerants and their chemical name

A. R-11, Trichloromonofluoromethane ($CC1_3F$)

B. R-12, Dichlorodifluoromethane ($CC1_2F_2$)

C. R-22, Monochlorodifluoromethane ($CHC1F_2$)

D. R-500, Refrigerant 500

E. R-502, Refrigerant 502

(NOTE: Refrigerant 500 and 502 are azeotropic mixtures of two halide refrigerants.)

F. R-717, Ammonia (NH_3)

III. Refrigerant cylinder color codes (Transparency 1)

A. R-11--Orange cylinder

B. R-12--White cylinder

C. R-22--Green cylinder

D. R-500--Yellow cylinder

E. R-502--Purple cylinder

F. R-717--Gray cylinder

IV. Refrigerant types and applications

A. R-11

1. Cleaning agent for contaminated systems

2. Refrigerant for large air-conditioning systems

B. R-12--Refrigerant for domestic refrigerators, freezers, and automobile air conditioners

C. R-22--Refrigerant for domestic and commercial air conditioners and freezers

INFORMATION SHEET

   D. R-500--Refrigerant for domestic and commercial air conditioners

   E. R-502--Refrigerant for commercial freezers and refrigerators

   (NOTE: This is generally found in low temperature equipment.)

   F. R-717--Industrial compression and absorption type refrigeration and air conditioning

V. Desirable characteristics of a refrigerant

   A. Nontoxic

   B. Nonflammable

   C. Nonexplosive

   D. Noncorrosive

   E. Low boiling temperature

   F. Chemically stable

   G. Mixes easily with oil

VI. Temperature-pressure chart (Transparencies 2, 3, and 4)

   A. Top of chart--Refrigerant type

   B. Left margin--Temperature

   C. Bold numbers--Pressure (in p.s.i.g.)

   D. Italics--Vacuum (in "Hg)

VII. Methods of leak detection

   A. Soap solution (Transparency 5)

   B. Halide torch (Transparency 6)

   C. Electronic leak detector (Transparency 7)

VIII. Safety precautions for refrigerant handling

   A. Do not drop cylinders

   B. Do not refill disposable refrigerant cylinders

   C. Do not heat cylinders with a torch

INFORMATION SHEET

D. Secure cylinders in a moving vehicle

E. Do not spray refrigerant on skin

F. Do not inhale refrigerant

G. Do not spray refrigerant into open flame

H. Do not mix refrigerants

I. Replace cylinder cap when not in use to protect valve

J. Do not lift or carry cylinder by valve

K. Secure cylinder to wall or bench

L. Have adequate ventilation

IX. Procedure for obtaining refrigeration system pressures (Transparency 8)

A. Obtain low side pressure or vacuum by connecting gauge set to a refrigeration system

1. Read pressure on 0-250 p.s.i.g. scale

2. Read vacuum on 0-30" Hg. scale

(NOTE: Hermetic refrigeration systems should not be allowed to run in a vacuum.)

B. Obtain high side pressure--Read pressure on 0-500 p.s.i.g. scale

(NOTE: The inner circle of numbers on the refrigeration gauges are temperature scales and can be read directly by aligning the gauge needle with the pressure and temperature.)

X. Methods of determining the type of refrigerant in a system

A. Read manufacturer's data plate

B. Read compressor data plate

C. Look at component parts

D. Use gauge pressures

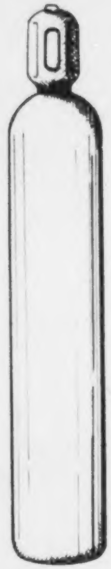
1. Install gauges

2. Read pressures

3. Convert pressures to temperature using temperature-pressure chart

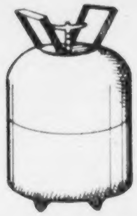
Refrigerant Drums

Standard Returnable



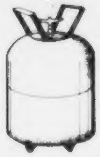
R-12 (white) 145 lbs
R-22 (green) 125 lbs
R-500 (yellow) 125 lbs
R-502 (purple) 125 lbs

50 lb Disposable



R-12 (white)
R-22 (green)
R-500 (yellow)
R-502 (Purple)

25 lb Disposable



R-12 (white)
R-22 (green)
R-500 (yellow)
R-502 (purple)
R-11 (orange)
Pressurized

Disposable

R-12 (white) 12 lbs
R-22 (green) 10 lbs
R-500 (yellow) 10 lbs
R-502 (purple) 10 lbs

Temperature-Pressure Chart

Vacuum---*Italic Figures* Gauge Pressure---Bold Figures

TEMPERATURE		REFRIGERANT				
	CCl_3F	CCl_2F_2	$CHClF_2$	(Azeotropic Mixtures)		NH_3
°F.	11	12	22	500	502	717
-60	-	*19.0*	*11.9*	-	*7.0*	*18.6*
-55	-	*17.3*	*9.1*	-	*3.6*	*16.6*
-50	-	*15.4*	*6.0*	-	0.0	*14.3*
-45	-	*13.3*	*2.6*	-	2.1	*11.7*
-40	*28.4*	*10.9*	0.6	*7.9*	4.3	*8.7*
-35	*28.1*	*8.3*	2.7	*4.8*	6.7	*5.4*
-30	*27.8*	*5.4*	5.0	*1.4*	9.4	*1.6*
-25	*27.3*	*2.3*	7.5	1.1	12.3	1.3
-20	*27.0*	0.5	10.3	3.1	15.5	3.6
-18	*26.9*	1.3	11.5	4.0	16.9	4.6
-16	*26.7*	2.0	12.7	4.9	18.3	5.6
-12	*26.2*	3.6	15.2	6.8	21.2	7.9
-10	*26.0*	4.4	16.6	7.8	22.8	9.0
- 8	*25.8*	5.3	18.0	8.8	24.4	10.3
- 6	*25.5*	6.2	19.4	9.9	26.0	11.6
- 4	*25.3*	7.1	20.9	11.0	27.7	12.9
- 2	*25.0*	8.1	22.5	12.1	29.4	14.3
0	*24.7*	9.2	24.1	13.3	31.2	15.7
1	*24.6*	9.7	24.9	13.9	32.2	16.5
2	*24.4*	10.2	25.7	14.5	33.1	17.2
3	*24.2*	10.7	26.6	15.1	34.1	18.0
4	*24.1*	11.2	27.4	15.7	35.0	18.8
5	*24.0*	11.8	28.3	16.4	36.0	19.6
6	*23.8*	12.3	29.2	17.0	37.0	20.4
7	*23.6*	12.9	30.1	17.7	38.0	21.2
8	*23.5*	13.5	31.0	18.4	39.0	22.1
9	*23.3*	14.0	32.0	19.0	40.0	22.9
10	*23.1*	14.6	32.9	19.7	41.1	23.8

Temperature-Pressure Chart

(Continued)

Vacuum---*Italic Figures* Gauge Pressure---Bold Figures

TEMPERATURE		REFRIGERANT				
	CCl_3F	CCl_2F_2	$CHClF_2$	(Azeotropic Mixture)		NH_3
°F.	11	12	22	500	502	717
11	*22.9*	15.2	33.9	20.5	42.2	24.7
12	*22.7*	15.8	34.9	21.2	43.2	25.6
13	*22.5*	16.5	35.9	21.9	44.3	26.5
14	*22.3*	17.1	36.9	22.6	45.4	27.5
15	*22.0*	17.7	37.9	23.4	46.6	28.4
16	*21.9*	18.4	38.9	24.2	47.7	29.4
17	*21.7*	19.0	40.0	24.9	48.9	30.4
18	*21.5*	19.7	41.1	25.7	50.1	31.4
19	*21.3*	20.4	42.2	26.5	51.2	32.5
20	*21.1*	21.0	43.3	27.3	52.4	33.5
21	*20.9*	21.7	44.4	28.2	53.7	34.6
22	*20.6*	22.4	45.5	29.0	54.9	35.7
23	*20.4*	23.2	46.7	29.8	56.2	36.8
24	*20.2*	23.9	47.8	30.7	57.4	37.9
25	*20.0*	24.6	49.0	31.6	58.7	39.0
26	*19.7*	25.4	50.2	32.4	60.0	40.2
27	*19.5*	26.1	51.5	33.3	61.4	41.4
28	*19.1*	26.9	52.7	34.3	62.7	42.6
29	*18.9*	27.7	54.0	35.2	64.1	43.8
30	*18.6*	28.5	55.2	36.1	65.4	45.0
31	*18.4*	29.3	56.5	37.0	66.8	46.3
32	*18.1*	30.1	57.8	38.0	68.2	47.6
33	*17.8*	30.9	59.2	39.0	69.7	48.9
34	*17.5*	31.7	60.5	40.0	71.1	50.2
35	*17.1*	32.6	61.9	41.0	72.6	51.6
36	*16.9*	33.4	63.3	42.0	74.1	52.9
37	*14.6*	34.3	64.4	43.1	75.6	54.3
38	*16.3*	35.2	66.1	44.1	77.1	55.7

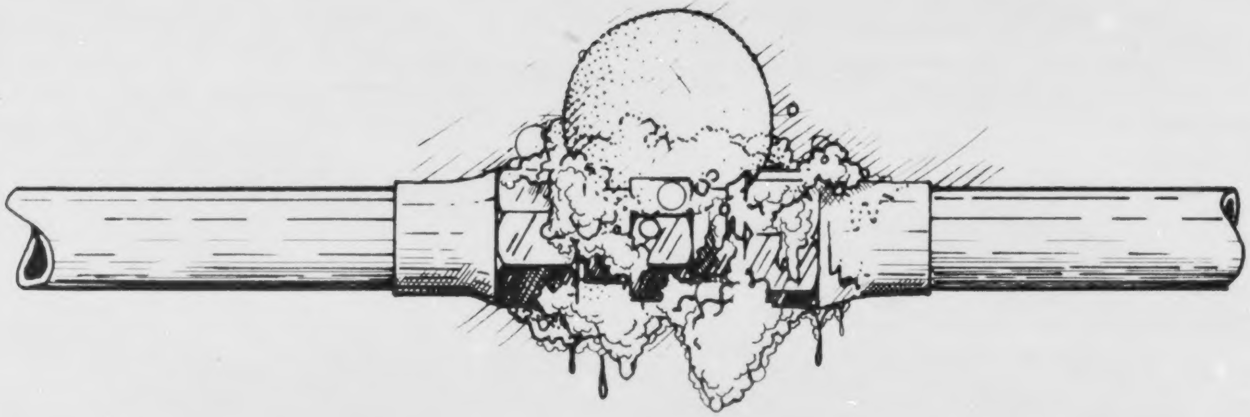
Temperature-Pressure Chart

(Continued)

Vacuum---*Italic Figures* Gauge Pressure---Bold Figures

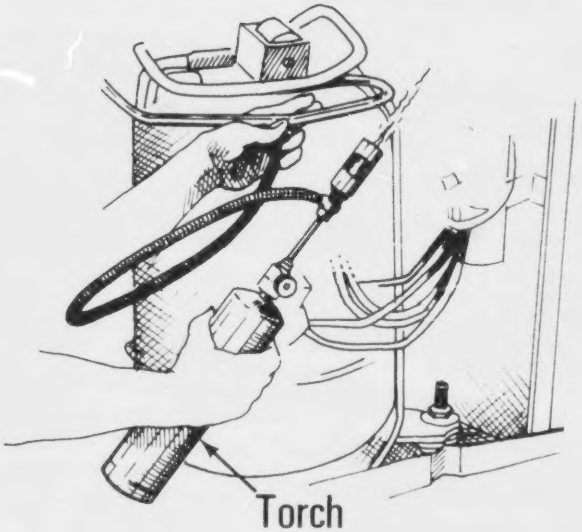
TEMPERATURE		REFRIGERANT				
	CCl_3F	CCl_2F_2	$CHClF_2$	(Azeotropic Mixtures)		NH_3
°F.	11	12	22	500	502	717
39	*16.0*	36.1	67.5	45.2	78.6	57.2
40	*15.6*	37.0	69.0	46.2	80.2	58.6
41	*15.3*	37.9	70.5	47.2	81.8	60.1
42	*15.0*	38.8	72.0	48.4	83.4	61.6
43	*14.7*	39.7	73.5	49.6	85.0	63.1
44	*14.3*	40.7	75.0	50.7	86.6	64.7
45	*13.9*	41.7	76.6	51.8	88.3	66.3
46	*13.5*	42.6	78.2	53.0	90.0	67.9
47	*13.2*	43.6	79.8	54.2	91.7	69.5
48	*12.8*	44.6	81.4	55.4	93.4	71.1
49	*12.5*	45.7	83.0	56.6	95.2	72.8
50	*12.0*	46.7	84.7	57.8	96.9	74.5
55	*10.0*	52.0	93.3	64.1	106.0	83.4
60	*7.7*	57.7	102.5	71.0	115.6	92.9
65	*5.3*	63.7	112.2	78.1	125.8	103.1
70	*2.6*	70.1	122.5	85.8	136.6	114.1
75	.4	76.9	133.4	93.9	148.0	125.8
80	1.6	84.1	145.0	102.5	159.9	138.3
85	3.2	91.7	157.2	111.5	172.5	151.7
90	5.0	99.7	170.1	121.2	185.8	165.9
95	6.8	108.2	183.7	131.3	199.8	181.1
100	8.9	117.1	197.9	141.9	214.4	197.2
105	11.1	126.5	212.9	153.1	229.8	214.2
110	13.4	136.4	228.7	164.9	245.8	232.3
115	15.8	146.7	245.3	177.4	262.7	251.5
120	18.5	157.6	262.6	190.3	280.3	271.7
125	21.2	169.0	280.7	204.0	298.7	293.1
130	24.3	181.0	299.3	218.2	318.0	-
135	27.4	193.5	316.6	232.1	338.1	-

Leak Detection Using a Soap Solution

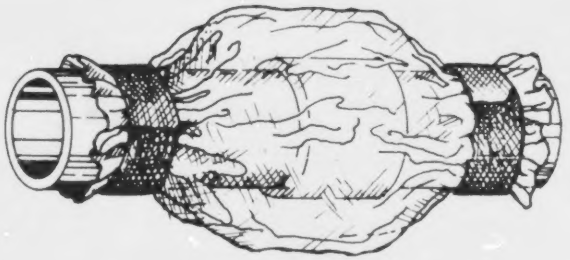


Foam is Placed on a Connection That is Suspected of Leaking. Note the Bubbles Which Indicate a Leak.

Leak Detection Using a Halide Torch

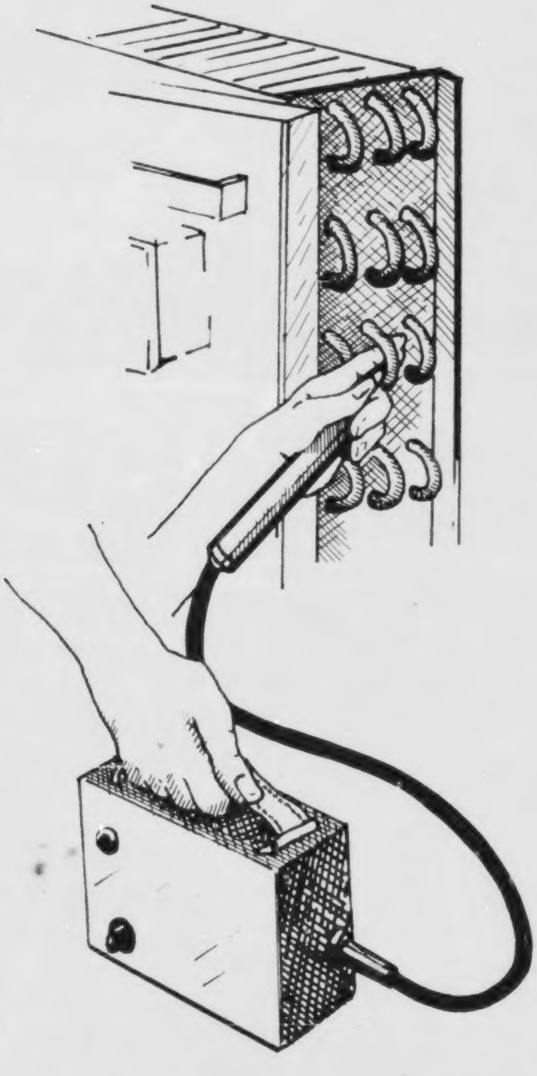


Checking for Leaks with a Halide Torch



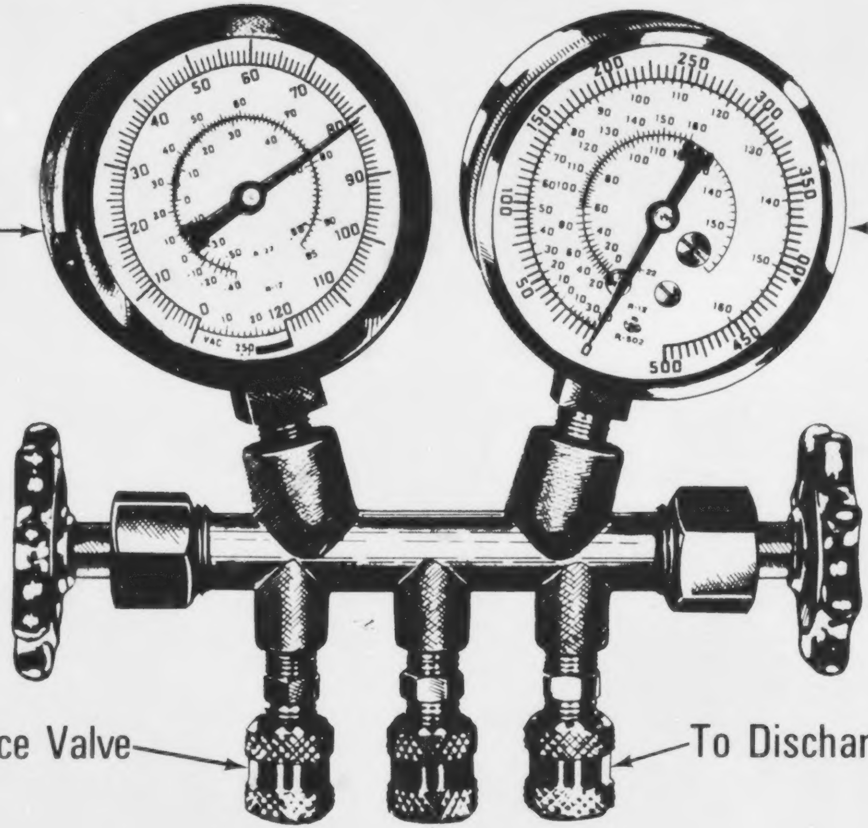
Cellophane-Enclosed Joint
Suspected of Leaking

Leak Detection Using an Electronic Leak Detector



Use of an Electronic Leak Detector

Reading Gauges


0
10
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120
250
VAC
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50
100
150
200
250
300
350
400
450
500

Compound Pressure Gauge

High Pressure Gauge

To Suction Service Valve

To Discharge Service Valve

To Vacuum Pump or Refrigerant Cylinder

TM - 8

ACR I - 121-F

REFRIGERANTS
UNIT III

ASSIGNMENT SHEET #1--LIST CYLINDER COLOR CODES

Give the cylinder color code for the following refrigerants.

	Refrigerant	Cylinder color
1.	R-11	____________
2.	R-12	____________
3.	R-22	____________
4.	R-500	____________
5.	R-502	____________
6.	R-717	____________

REFRIGERANTS
UNIT III

ASSIGNMENT SHEET #2--COMPUTE TEMPERATURE-PRESSURE PROBLEMS

The low side pressure can be obtained by finding the evaporator temperature and going straight across to the proper refrigerant column.

Example: Air conditioner using R-22, with a 350°F evaporator, low side pressure should read 62 p.s.i.g.

The low side temperature can be obtained by finding the pressure reading and going straight across to the temperature column. The high side pressure can be obtained by finding the ambient at the condensor, adding 35 degrees, and going straight across to the proper refrigerant column.

Example: Air conditioner using R-12 has an ambient temperature of 55°. Adding 35° would give an evaporator temperature of 90°. The high side pressure is 100 p.s.i.g.

The high side temperature can be obtained by finding the high side pressure reading and going straight across to the temperature column.

(NOTE: To check for proper ambient subtract 35°F from refrigerant temperature. 35°F is the recommended temperature for proper heat transfer for air-cooled condensers and 20°F for water-cooled condensers.)

Use the temperature-pressure chart to solve the following problems, showing all work. Round all numbers off to nearest whole number.

1. Refrigerator
    A. Refrigerant R-12
    B. Evaporator -6°F
    C. Ambient 75°F
    D. Low side pressure ____________ p.s.i.g.
    E. High side pressure ____________ p.s.i.g.

2. Freezer
    A. Refrigerant R-12
    B. Evaporator -10°F
    C. Ambient 90°F
    D. Low side pressure ____________ p.s.i.g.
    E. High side pressure ____________ p.s.i.g.
    F. Temperature of condensing vapor ____________ °F

3. Air conditioner
    A. Refrigerant R-12
    B. Evaporator 38°F
    C. Ambient 95°F
    D. Low side pressure ____________ p.s.i.g.
    E. High side pressure ____________ p.s.i.g.

ASSIGNMENT SHEET #2

4. Air Conditioner
   A. Refrigerant R-22
   B. Evaporator 38°F
   C. Ambient 85°F
   D. Low side pressure ___________ p.s.i.g.
   E. High side pressure ___________ p.s.i.g.

5. Commercial refrigerator
   A. Refrigerant R-12
   B. Evaporator 38°F
   C. Ambient 80°F
   D. Low side pressure ___________ p.s.i.g.
   E. High side pressure ___________ p.s.i.g.
      1) Water-cooled condenser
      2) Add 20°F instead of 35°F

6. Air conditioner
   A. Refrigerant R-500
   B. Evaporator 38°F
   C. Ambient 100°F
   D. Low side pressure ___________ p.s.i.g.
   E. High side pressure ___________ p.s.i.g.

7. Commercial freezer
   A. Refrigerant R-502
   B. Evaporator -40°F
   C. Ambient 70°F
   D. Low side pressure ___________ p.s.i.g.
   E. High side pressure ___________ p.s.i.g.

8. Commercial refrigerator
   A. Refrigerant R-500
   B. Evaporator 40°F
   C. Ambient 65°F
   D. Low side pressure ___________ p.s.i.g.
   E. High side pressure ___________ p.s.i.g.

9. Freezer
   A. Refrigerant R-22
   B. Evaporator -20°F
   C. Ambient 75°F
   D. Low side pressure ___________ p.s.i.g.
   E. High side pressure ___________ p.s.i.g.

10. Air conditioner
   A. Refrigerant R-22
   B. Evaporator 40°F
   C. Ambient 100°F
   D. Low side pressure ___________ p.s.i.g.
   E. High side pressure ___________ p.s.i.g.

REFRIGERANTS
UNIT III

ANSWERS TO ASSIGNMENT SHEETS

Assignment Sheet #1

1. Orange
2. White
3. Green
4. Yellow
5. Purple
6. Gray

Assignment Sheet #2

1. D. 6
   E. 136
2. D. 4
   E. 169
   F. 125
3. D. 35
   E. 181
4. D. 66
   E. 260
5. D. 35
   E. 117
6. D. 44
   E. 232
7. D. 4
   E. 230
8. D. 46
   E. 141
9. D. 10
   E. 229
10. D. 69
    E. 317

REFRIGERANTS
UNIT III

JOB SHEET #1--PRESSURE CHECK A DOMESTIC REFRIGERATOR

I. Tools and materials

   A. Refrigeration gauge set

   B. Open end wrench

   C. Refrigeration ratchet

   D. Shop cloth

   E. Thermometer

   F. Refrigerator

   G. Temperature-pressure card

II. Procedure

   (NOTE: Refrigerator should run for thirty minutes prior to taking readings.)

   A. Locate data plate

      (NOTE: Data plates are generally located below the door behind the kick plate, but they may also be located inside the cabinet on the lower left hand side or on the condenser.)

   B. Obtain manufacturer's name and model number

   C. Obtain type of refrigerant

   D. Place thermometer in evaporator compartment

   E. Obtain room temperature in the area of refrigerator

   F. Use appropriate wrench to remove cap from low side service valve gauge port

   G. Tighten hose from compound gauge on low side service port

   H. Use refrigeration ratchet to crack service valve

   I. Install pressure gauge on the high side in the same manner as the compound gauge was installed

JOB SHEET #1

J. Record all information in spaces provided below

K. Have instructor evaluate

L. Back seat service valve

M. Place a cloth around hose end and gauge port when removing hoses

N. Replace service port caps

O. Tighten caps finger tight and then a quarter of a turn with a wrench

P. Clean up and put away tools

Manufacturer's name and model number ______________________________

Type of refrigerant ______________________________________

Evaporator temperature __________ °F

Low side pressure __________ p.s.i.g.

High side pressure __________ p.s.i.g.

Ambient temperature __________ °F

REFRIGERANTS
UNIT III

JOB SHEET #2--PRESSURE CHECK AN AIR CONDITIONER

I. Tools and materials

- A. Refrigeration gauge set
- B. Open end wrench
- C. Refrigeration ratchet
- D. Shop cloth
- E. Thermometer
- F. Air conditioner
- G. Temperature-pressure card

II. Procedure

(NOTE: Air conditioner should run for thirty minutes prior to taking readings)

A. Locate data plate

(NOTE: Data plates on window air conditioners are generally found behind the front grill, and data plates on central air conditioners are found on the side of the condensing unit close to the removable service panel.)

B. Obtain manufacturer's name and model number

C. Obtain type of refrigerant

D. Place thermometer in supply air

E. Obtain ambient in the area of the condenser

(NOTE: This temperature reading should not be of the discharge air from the condenser.)

F. Use open end wrench to remove cap from low side and high side service valve gauge ports

G. Tighten hose from compound gauge on low side service port

H. Use refrigeration ratchet to crack service valve

JOB SHEET #2

I. Install pressure gauge on the high side in the same manner as the compound gauge was installed

J. Record all information in spaces provided below

K. Have instructor evaluate

L. Back seat service valve

M. Place a cloth around hose end and gauge port when removing hoses

N. Replace service port caps

O. Tighten caps finger tight and then a quarter of a turn more with a wrench

P. Clean up and put away tools

Manufacturer's name and model number ______________________________

Type of refrigerant ____

Evaporator temperature __________ °F

Low side pressure __________ p.s.i.g.

High side pressure __________ p.s.i.g.

Ambient temperature __________ °F

REFRIGERANTS
UNIT III

JOB SHEET #3--PRESSURE CHECK A COMMERCIAL REFRIGERATOR

I. Tools and materials

   A. Refrigeration gauge set

   B. Open end wrench

   C. Refrigeration ratchet

   D. Shop cloth

   E. Thermometer

   F. Commercial refrigerator

   G. Temperature-pressure card

II. Procedure

   (NOTE: Refrigerator should run for thirty minutes prior to taking readings.)

   A. Locate data plate

      (NOTE: Data plates are generally located in the area of the condensing unit or inside the refrigerator.)

   B. Obtain manufacturer's name and model number

   C. Obtain type of refrigerant

   D. Place thermometer in evaporator compartment

   E. Obtain room temperature in the area of refrigerator

   F. Use a wrench to remove cap from low side service valve gauge port

   G. Tighten hose from compound gauge on low side service port

   H. Use refrigeration ratchet to crack service valve

   I. Install pressure gauge on the high side in the same manner as the compound gauge was installed

JOB SHEET #3

J. Record all information in spaces provided below

K. Have instructor evaluate

L. Back seat service valve

M. Place a cloth around hose end and gauge port when removing hoses

N. Replace service port caps

O. Tighten caps finger tight and then a quarter of a turn more with a wrench

P. Clean up and put away tools

Manufacturer's name and model number ______________________________

Type of refrigerant ____

Evaporator temperature __________ °F

Low side pressure __________ p.s.i.g.

High side pressure __________ p.s.i.g.

Ambient temperature __________ °F

REFRIGERANTS
UNIT III

JOB SHEET #4--DETERMINE TYPE OF REFRIGERANT USED IN A CENTRAL AIR CONDITIONER

I. Tools and materials

   A. Refrigeration gauge set

   B. Open end wrench

   C. Refrigeration ratchet

   D. Mirror

   E. Central air conditioner

   F. Temperature-pressure card

II. Procedure

   A. Locate manufacturer's data plate

   (NOTE: Manufacturer's data plates are usually found on outside of condensing unit.)

   B. Copy refrigerant type

   C. Locate compressor data plate

   D. Remove inspection panel or case

   (NOTE: Compressor data plates are generally located on the top of the compressor.)

   E. Copy refrigerant type if given

   F. Locate flow control

   (NOTE: Expansion valve is at the evaporator inlet and the liquid line valve is in liquid line. Capillary tubes will not give refrigerant type.)

   G. Copy refrigerant type

   F. Obtain refrigeration pressure readings

   (NOTE: Air conditioner should run fifteen minutes prior to making pressure checks.)

JOB SHEET #4

1. Use a wrench to remove cap from low side service valve gauge port
2. Tighten hose from compound gauge on low side service port
3. Use refrigeration ratchet to crack service valve
4. Install pressure gauge on the high side in the same manner as the compound gauge was installed
5. Record all information in spaces provided below

G. Have instructor evaluate procedure and readings

H. Back seat service valve

I. Place a cloth around hose end and gauge port when removing hoses

J. Replace service port caps

K. Tighten caps finger tight and then a quarter of a turn more with a wrench

L. Clean up and put away tools

Type of refrigerant from manufacturer's data plate ____________________________

Type of refrigerant from compressor data plate ______________________________

Type of refrigerant from the expansion valve or other flow control ____

Type of refrigerant by checking pressures and converting on the temperature-pressure card ____

REFRIGERANTS
UNIT III

TEST

1. Match the terms on the right to the correct definitions.

_____a. Group of chemicals, of which the most active is fluorine

_____b. Monochlorodifluoromethane, $CHC1F_2$, a halide refrigerant

_____c. Ammonia, NH_3, a nonhalide refrigerant

_____d. Container in which refrigerant is purchased and dispensed

_____e. Mixtures of halide refrigerants in order to make a single refrigerant

_____f. Dichlorodifluoromethane, $CC1_2F_2$, a halide refrigerant

_____g. Refrigerant compound containing one or more carbon atoms and fluorine

_____h. Special dehydrated oil used in a refrigeration mechanism for lubrication and cooling

_____i. Group of refrigerants containing halogen chemicals

_____j. Any substance which produces a refrigerating effect by its absorption of heat while evaporating

_____k. Trichloromonofluoromethane, $CC1_3F$, a halide refrigerant

_____l. Temperature of air which surrounds an object on all sides

_____m. Refrigerant container which cannot be refilled

1. R-11
2. Halide refrigerants
3. Azeotropic mixtures
4. Ambient temperature
5. R-717
6. Halogen
7. R-12
8. Fluorocarbon
9. Refrigerant
10. Disposable refrigerant cylinder
11. Refrigerant oil
12. Refrigerant cylinder
13. R-22

2. Match the common types of refrigerants on the right to their chemical name.

______a. Trichloromonofluoromethane (CCl_3F)

______b. Dichlorodifluoromethane (CCl_2F_2)

______c. Monochlorodifluoromethane ($CHClF_2$)

______d. Refrigerant 500

______e. Refrigerant 502

______f. Ammonia (NH_3)

1. R-500
2. R-717
3. R-11
4. R-12
5. R-22
6. R-502

3. Match the cylinder color codes on the left to the types of refrigerants.

______a. R-500

______b. R-717

______c. R-502

______d. R-12

______e. R-22

______f. R-11

1. Yellow
2. Gray
3. Green
4. Orange
5. White
6. Purple

4. Match the types of refrigerants on the right to their applications.

______a. Refrigerant for domestic and commercial air conditioners

______b. Cleaning agent for contaminated systems and a refrigerant for large air-conditioning systems

______c. Refrigerant for domestic and commercial air conditioners and freezers

______d. Industrial compression and absorption type refrigeration and air conditioning

______e. Refrigerant for commercial freezers and refrigerators

______f. Refrigerant for domestic refrigerators, freezers, and automobile air conditioners

1. R-500
2. R-12
3. R-502
4. R-717
5. R-22
6. R-11

5. List seven desirable characteristics of a refrigerant.

a.

b.

c.

d.

e.

f.

g.

6. Match sections of the temperature-pressure chart to the name.

______a.	Bold numbers	1.	Vacuum (in "Hg)
______b.	Top of chart	2.	Pressure (in p.s.i.g.)
______c.	Italics	3.	Temperature
______d.	Left margin	4.	Refrigerant type

7. Name three methods of leak detection.

a.

b.

c.

8. List eight safety precautions for refrigerant handling.

a.

b.

c.

d.

e.

f.

g.

h.

9. Describe the procedure for obtaining refrigeration system pressures.

10. List three methods of determining what type of refrigerant is in a system.

    a.

    b.

    c.

11. Demonstrate the ability to:

    a. Compute temperature-pressure problems.

    b. Pressure check a domestic refrigerator.

    c. Pressure check an air conditioner.

    d. Pressure check a commercial refrigerator.

    e. Determine type of refrigerant used in a central air conditioner.

    (NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

REFRIGERANTS
UNIT III

ANSWERS TO TEST

1. a. 6
   b. 13
   c. 5
   d. 12
   e. 3
   f. 7
   g. 8
   h. 11
   i. 2
   j. 9
   k. 1
   l. 4
   m. 10

2. a. 3
   b. 4
   c. 5
   d. 1
   e. 6
   f. 2

3. a. 1
   b. 2
   c. 6
   d. 5
   e. 3
   f. 4

4. a. 1
   b. 6
   c. 5
   d. 4
   e. 3
   f. 2

5. a. Nontoxic
   b. Nonflammable
   c. Nonexplosive
   d. Noncorrosive
   e. Low boiling temperature
   f. Chemically stable
   g. Mixes easily with oil

6. a. 2
   b. 4
   c. 1
   d. 3

7. a. Soap solution
   b. Halide torch
   c. Electronic leak detector

8. Any eight of the following:
    a. Do not drop cylinders
    b. Do not refill disposable refrigerant cylinders
    c. Do not heat cylinders with a torch
    d. Secure cylinders in a moving vehicle
    e. Do not spray refrigerant on skin
    f. Do not inhale refrigerant
    g. Do not spray refrigerant into open flame
    h. Do not mix refrigerants
    i. Replace cylinder cap when not in use to protect valve
    j. Do not lift or carry cylinder by valve
    k. Secure cylinder to wall or bench
    l. Have adequate ventilation
9. Description should include:
    a. Obtain low side pressure or vacuum by connecting gauge set to a refrigeration system
        1) Read pressure on 0-250 p.s.i.g. scale
        2) Read vacuum on 0-30" Hg scale
    b. Obtain high side pressure--Read pressure on 0-500 p.s.i.g. scale
10. Any three of the following:
    a. Read manufacturer's date plate
    b. Read compressor data plate
    c. Look at component parts
    d. Use gauge pressures
        1) Install gauges
        2) Read pressures
        3) Convert pressures to temperature using temperature-pressure chart
11. Performance skills evaluated to the satisfaction of the instructor

EVACUATION
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with evacuation to the correct definitions and list the reasons for evacuating. He should also be able to describe the effects of ambient temperature on evacuation, describe the three types of vacuum indicators, and use the vacuum steam table. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with evacuation to the correct definitions.
2. List three reasons for evacuating a refrigeration system.
3. Select the effects of moisture in a refrigeration system.
4. Select the effects of air in a refrigeration system.
5. Describe the effects ambient temperature has on proper evacuation.
6. Distinguish between low and high vacuum pumps.
7. List six steps in the care of vacuum pumps.
8. Describe three types of vacuum indicators.
9. Demonstrate the ability to:
    a. Use the vacuum steam table.
    b. Evacuate a refrigeration system and use a mercury manometer.
    c. Evacuate a refrigeration system and use an electronic vacuum gauge.
    d. Triple evacuate.

EVACUATION
UNIT IV

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information, assignment, and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information and assignment sheets.
- F. Demonstrate and discuss the procedures outlined in the job sheets.
- G. Demonstrate boiling water with a vacuum pump.
- H. Demonstrate the use of vacuum pumps and vacuum indicators.
- I. Use empty refrigerant cylinder for demonstrating triple evacuation.
- J. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete assignment and job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
    1. TM 1--Vacuum Steam Table
    2. TM 2--Single Stage Low Vacuum Pumps

    3. TM 3--Two Stage High Vacuum Pumps

    4. TM 4--Vacuum Indicators

  D. Assignment Sheet #1--Use the Vacuum Steam Table

  E. Answers to assignment sheet

  F. Job sheets

    1. Job Sheet #1--Evacuate a Refrigeration System and Use a Mercury Manometer

    2. Job Sheet #2--Evacuate a Refrigeration System and Use an Electronic Vacuum Gauge

    3. Job Sheet #3--Triple Evacuate

  G. Test

  H. Answers to test

II. References:

  A. *Refrigeration Service: Part 1.* Benton Harbor, Michigan: Whirlpool Corp., 1970.

  B. Bishop, Robert W. *Fundamentals of Dehydrating a Refrigerant System.* Montpelier, Ohio: Robinair Manufacturing Corp., 1969.

  C. Woodroof, William Walton. *Servicing Comfort Cooling Systems.* 2nd ed. Columbus, Ohio: NHAW Home Study Institute, 1974.

EVACUATION
UNIT IV

INFORMATION SHEET

I. Terms and definitions

   A. Vacuum--Pressures below the atmospheric pressure of 14.7 p.s.i., indicated by inches of mercury ("Hg) on a 0 to 30" scale

   B. Evacuation--Removal of air and moisture from a refrigeration system

   C. Micron--Unit of pressure measurement in thousandths of millimeters of mercury

   D. Single stage pump--Discharges directly into the atmosphere and is capable of pulling down to 1,000 microns

   E. Two stage pump--Discharges into a second vacuum and is capable of pulling down to .1 microns

   F. Mercury manometer--Pressure measuring instrument consisting of a "U" shaped glass tube and mercury

   G. Noncondensables--Substances that remain in a gaseous form in a refrigeration system, such as nitrogen and oxygen

   (Caution: Never use oxygen to pressurize a refrigeration system.)

   H. Vacuum pump oil--Nonfoaming, nonadditive oil designed for use in vacuum pumps

   I. Low vacuum--Vacuum of 2,000 microns or more, obtainable with a single stage pump

   J. High vacuum--Vacuum of 2,000 to .1 microns, requiring a two stage pump

   K. Absolute pressure--Gauge pressure plus the atmospheric pressure of 14.7 p.s.i.

II. Reasons for evacuating a refrigeration system

   A. To remove noncondensables from the system

   B. To remove oil trapped refrigerant

   C. To remove moisture from the system

INFORMATION SHEET

III. Effects of moisture in a refrigeration system

   A. Ice crystals will form at expansion point stopping refrigerant flow

   B. Combined with halogen type refrigerants it creates hydrochloric and hydrofluoric acid

   C. Combined with refrigerant oil and heat, it creates sludge

   D. Causes deterioration of metal parts inside the refrigeration system

IV. Effects of air in a refrigeration system

   A. Increases the discharge pressure

   (NOTE: When compressed in the refrigeration system, air can increase the discharge pressure.)

   B. Noncondensables combined with moisture will accelerate the formation of corrosion, acid, copperplating, and sludge

   C. Will take up space in condenser

   (NOTE: Trapped air will take up space in the condenser needed for the condensing of the refrigerant.)

V. Effects of ambient temperature on proper evacuation (Transparency 1)

   A. Moisture is removed in a vapor state

   B. Boiling temperature decreases as the pressure decreases

   C. Increasing the ambient temperature will decrease evacuation time

   (NOTE: The entire system must be the same temperature or the moisture will tend to collect at the area of lowest temperature.)

VI. Low and high vacuum pumps

   A. Low vacuum (Transparency 2)

      1. Single stage

      2. Generally of the compressor type

      (NOTE: Do not use a compressor out of a refrigeration system as a vacuum pump.)

      3. Rated at 1 cubic foot per minute (c.f.m.) or less

      (NOTE: The c.f.m. rating of a vacuum pump is its displacement.)

INFORMATION SHEET

B. High vacuum (Transparency 3)

1. Single stage or two stage

2. Belt or direct coupling drive

3. Rated at 1 to 5 c.f.m.

(NOTE: The rate of evacuation of any vacuum pump is directly related to the size of the line connecting it to the system as shown in table 1.)

TABLE 1

Pump Displ.	Conn. Line (6')	Final Absolute Pressure	
		Low Vacuum	High Vacuum
1 CFM	1/4" I.D.	57 min.	78 min.
2 CFM	1/4" I.D.	39 min.	56 min.
5 CFM	1/4" I.D.	28 min.	43 min.
1 CFM	3/8" I.D.	40 min.	51 min.
2 CFM	3/8" I.D.	22 min.	29 min.
5 CFM	3/8" I.D.	12 min.	16 min.
1 CFM	1/2" I.D.	37 min.	45 min.
2 CFM	1/2" I.D.	19 min.	23 min.
5 CFM	1/2" I.D.	8 min.	10 min.

VII. Care of vacuum pumps

A. Check to see if the pump will pull a vacuum on itself

(NOTE: This procedure is sometimes referred to as dead heading the pump.)

B. Change oil after every extensive evacuation

C. Keep pump clean

D. Keep caps on the inlet and outlet ports

E. Do not discharge refrigerant through the vacuum pump

F. Do not operate vacuum pump with a low oil level

VIII. Types of vacuum indicators (Transparency 4)

A. Compound gauge

1. Used in conjuction with other vacuum indicators

2. Accurate to 25" Hg

INFORMATION SHEET

3. Should not be sole indicator

4. Vacuum is read on the 0 to 30" part of the gauge

B. Mercury manometer

1. Accurate below 25" Hg

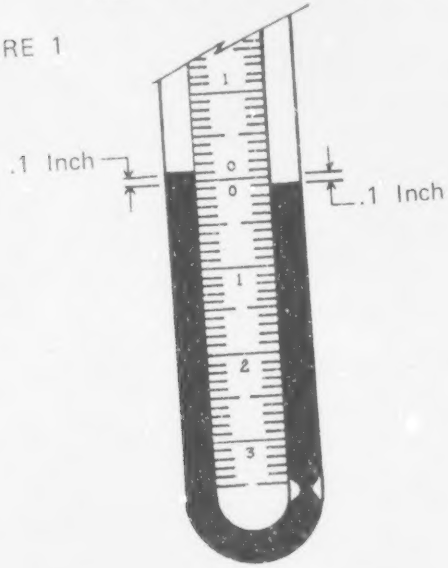
2. Keep capped when not in use

3. Must be kept in vertical position when using

4. Vacuum is read directly

Example: Add the amount of mercury above zero on the left to the amount below zero on the [illegible] and then subtract from 30 inches

FIGURE 1



(NOTE: In Figure 1 the left side reads .1 inch above zero and the right side .1 inch below zero. Add these two figures together and subtract from 30. The answer would be 29.8" Hg.)

5. Will indicate a leak or moisture still in the system after the pump is shut off

   a. No change in reading indicates the system is okay

   b. Reading returns to atmospheric pressure indicates a leak

   c. Slight change in reading indicates moisture still in the system

INFORMATION SHEET

C. Electronic vacuum gauge

1. Accurate below 29" Hg
2. Gives accurate readings to 50 microns
3. Use with high vacuum pumps
4. Durable enough for field use

   (NOTE: Do not allow refrigerant pressure to enter the vacuum sensor as this would destroy it.)

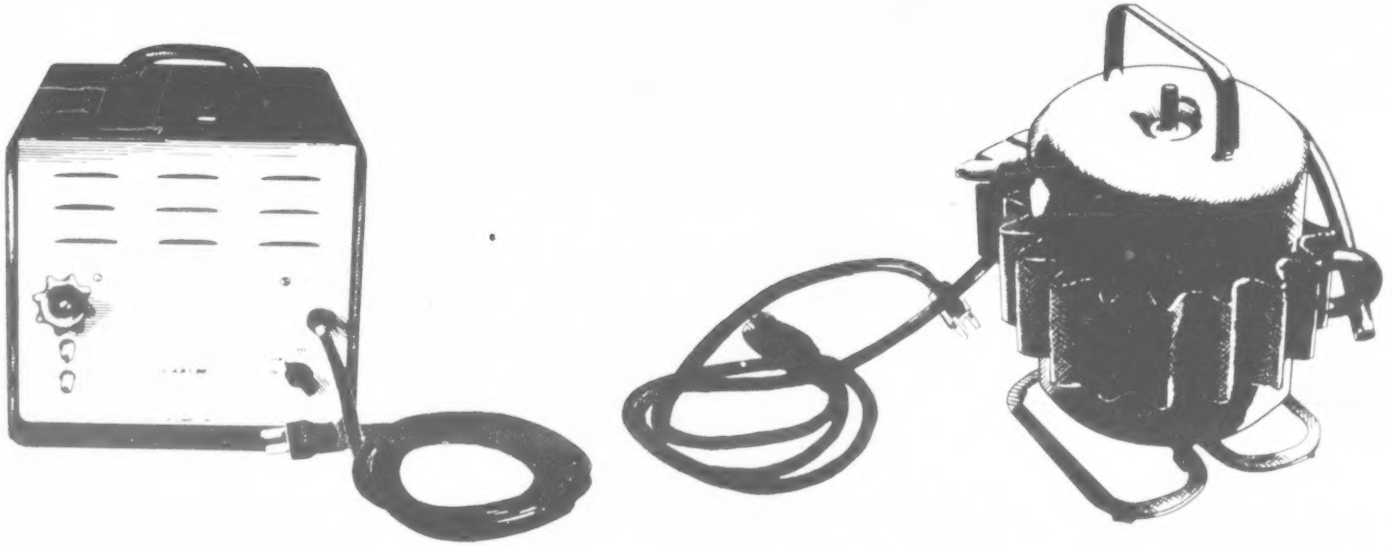
Vacuum Steam Table

Temperature In °F.	Inches of Mercury	Microns*
212	29.92	759,968
205	25.00	635,000
194	20.69	525,526
176	13.98	355,092
158	9.20	233,680
140	5.88	149,352
122	3.64	92,456
104	2.17	55,118
86	1.25	35,560
80	1.00	25,400
76	.90	22,860
72	.80	20,320
69	.70	17,780
64	.60	15,240
59	.50	12,700
53	.40	10,160
45	.30	7,620
32	.18	4,572
21	.10	2,540
6	.05	1,270
−24	.01	254
−35	.005	127
−60	.001	25.4
−70	.0005	12.7
−90	.0001	2.54

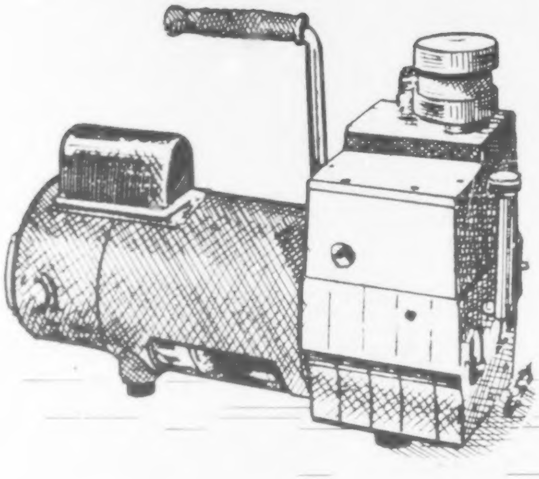
*Remaining pressure in system in microns

1.000 inch = 25,400 microns = 2.540 CM = 25.40 MM
.100 inch = 2,540 microns = .254 CM = 2.54 MM
.039 inch = 1,000 microns = .100 CM = 1.00 MM

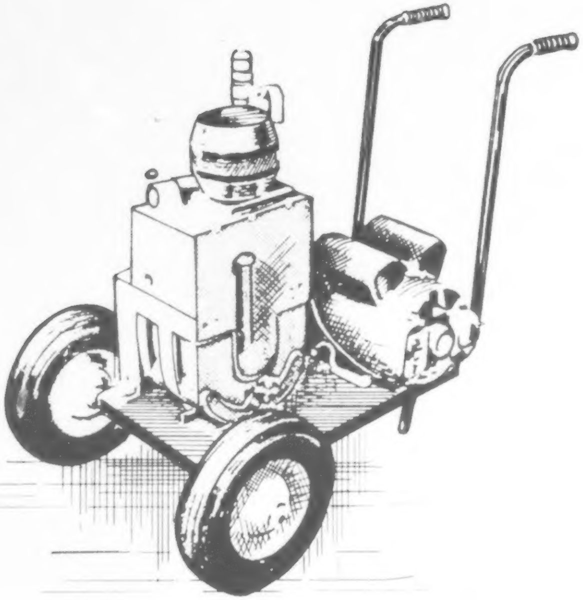
Single Stage Low Vacuum Pumps



Two Stage High Vacuum Pumps



759



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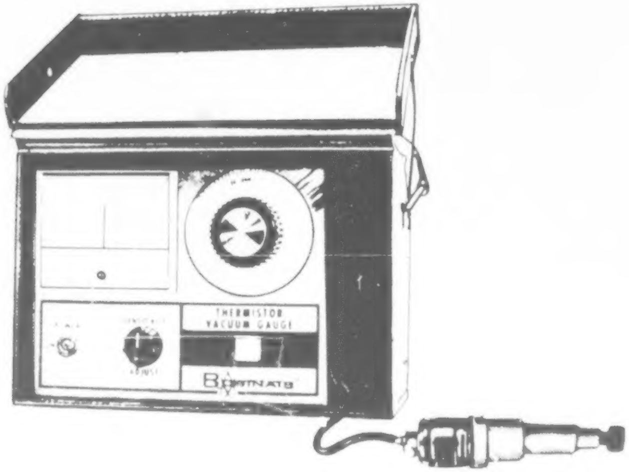
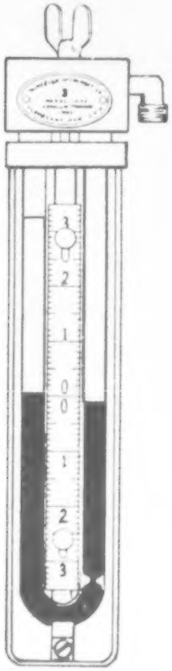
Vacuum Indicators

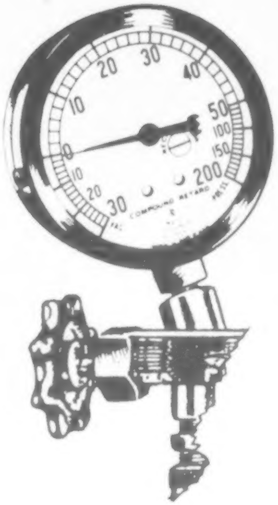
Electronic Vacuum Gauge


THERMISTOR
VACUUM GAUGE

Mercury Manometer



Compound Gauge


10
20
30
40
50
100
150
200
0
10
20
30
COMPOUND RETARD

EVACUATION
UNIT IV

ASSIGNMENT SHEET #1--USE THE VACUUM STEAM TABLE

Use the chart below to arrive at the answers to the problems. When using the vacuum steam table the inches of mercury are subtracted from 30.

Example: Water would boil at what temperature if there were a vacuum of 29.20" Hg on the system?

$$\begin{array}{r} 30.00 \\ -29.20 \\ \hline .80 \end{array}$$

Answer: 72°F

VACUUM STEAM TABLE

Temperature in F.	Inches of Mercury	Microns*
122	3.64	92,456
104	2.17	55,118
86	1.25	35,560
80	1.00	25,400
76	.90	22,860
72	.80	20,320
69	.70	17,780
64	.60	15,240
59	.50	12,700

1. How much vacuum would have to be pulled on a system when the ambient is 59°F?

2. A micron reading of 25,400 would be how many inches of mercury on the mercury manometer?

3. The ambient temperature at the condensing unit is 86°F and the ambient at the evaporator is 64°F. How much vacuum will need to be pulled?

ASSIGNMENT SHEET #1

4. To properly evacuate a system at 29" Hg what must the ambient temperature be?

5. In a shop with 70°F ambient a vacuum pump that will only pull 28" Hg, is sufficient dehydration possible?

EVACUATION
UNIT IV

ANSWERS TO ASSIGNMENT SHEET

1. 29.5" Hg
2. 29" Hg
3. 29.4" Hg
4. 80°F
5. No

EVACUATION
UNIT IV

JOB SHEET #1--EVACUATE A REFRIGERATION SYSTEM AND USE A MERCURY MANOMETER

I. Tools and materials

- A. Refrigeration gauge set
- B. Refrigeration ratchet
- C. Open end wrench
- D. Vacuum pump
- E. Mercury manometer
- F. Refrigeration system

II. Procedure

- A. Attach refrigeration gauge set to system
- B. Crack service valves
- C. Discharge any refrigerant pressure that may exist
- D. Connect gauge set center hose to vacuum pump inlet port
- E. Remove cap from vacuum pump outlet port
- F. Start the vacuum pump
- G. Open the high side refrigeration gauge set valve
- H. When the compound gauge shows a vacuum of 5" Hg or more, open the low side refrigeration gauge set valve

  (NOTE: If the compound gauge does not show a vacuum in a few minutes after operation, turn off the pump and pressurize the system to check for restrictions.)

- I. After a vacuum of 25" Hg has been reached, the mercury manometer should be used for accuracy
- J. Evacuate to 29" Hg
- K. Evacuate for approximately twenty minutes after reaching 29" Hg

JOB SHEET #1

L. Close refrigeration gauge set valves

M. Turn off the vacuum pump

N. If vacuum indicator returns to atmospheric pressure, there is a leak

O. If vacuum indicator raises 3 to 5" Hg, then stops, moisture is still present in the system

P. Check with the instructor before continuing

EVACUATION
UNIT IV

JOB SHEET #2-EVACUATE A REFRIGERATION SYSTEM AND USE AN ELECTRONIC VACUUM GAUGE

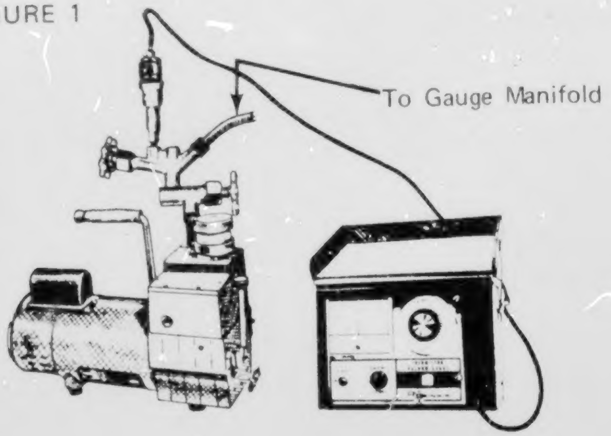
I. Tools and materials

- A. Refrigeration gauge set
- B. Refrigeration ratchet
- C. Open end wrench
- D. Vacuum pump
- E. Electronic vacuum gauge
- F. Refrigeration system

II. Procedure

- A. Attach refrigeration gauge set to system
- B. Crack service valves
- C. Discharge any refrigerant pressure that may exist
- D. Connect electronic vacuum gauge to system (Figure 1)

FIGURE 1



JOB SHEET #2

E. Connect refrigeration gauge set center hose to vacuum pump inlet port

F. Remove cap from vacuum pump outlet port

G. Start the vacuum pump

H. Open the high side refrigeration gauge set valve

I. When the compound gauge shows a vacuum of 5" Hg or more, open the low side refrigeration gauge set valve

J. After a vacuum of 29" Hg has been reached, the electronic vacuum gauge should be used for accuracy

K. Evacuate to 500 microns

L. Evacuate for approximately twenty minutes after reaching 500 microns

M. Close refrigeration gauge set valves

N. Turn off vacuum pump

O. Check with instructor before continuing

EVACUATION
UNIT IV

JOB SHEET #3--TRIPLE EVACUATE

I. Tools and materials

- A. Refrigeration gauge set
- B. Refrigeration ratchet
- C. Open end wrench
- D. Vacuum pump
- E. Mercury manometer
- F. Refrigeration system

II. Procedure

- A. Attach refrigeration gauge set to system
- B. Crack service valves
- C. Discharge any refrigerant pressure that may exist
- D. Connect gauge set center hose to vacuum pump inlet port
- E. Remove cap from vacuum pump outlet port
- F. Start the vacuum pump
- G. Open the high side refrigeration gauge set valve
- H. When the compound gauge shows a vacuum of 5" Hg or more, open the low side refrigeration gauge set valve
- I. After a vacuum of 25" Hg has been reached, the mercury manometer should be used for accuracy
- J. Evacuate to 29" Hg
- K. Evacuate for approximately twenty minutes after reaching 29" Hg
- L. Close refrigeration gauge set valves
- M. Turn off the vacuum pump
- N. Disconnect center hose from vacuum pump

JOB SHEET #3

O. Connect center hose to refrigerant drum

P. Purge air from center hose

Q. Open the high side refrigeration gauge set valve

R. Pressurize system to 5 p.s.i.g.

S. Allow system to set for 5 minutes

T. Discharge refrigerant

U. Repeat steps "D" through "T" one more time

V. Repeat steps "D" through "S"

W. Check with the instructor after the process has been completed three times

EVACUATION
UNIT IV

TEST

1. Match the terms on the right to the correct definitions.

_____a. Removal of air and moisture from a refrigeration system

_____b. Pressure measuring instrument consisting of a "U" shaped glass tube and mercury

_____c. Nonfoaming, nonadditive oil designed for use in vacuum pumps

_____d. Vacuum of 2,000 microns or more, obtainable with a single stage pump

_____e. Substances that remain in a gaseous form in a refrigeration system, such as nitrogen and oxygen

_____f. Discharges into a second vacuum and is capable of pulling down to .1 microns

_____g. Pressure below the atmospheric pressure of 14.7 p.s.i., indicated by inches of mercury ("Hg) on a 0 to 30" scale

_____h. Vacuum of 2,000 to .1 microns, requiring a two stage pump

_____i. Unit of pressure measurement in thousandths of millimeters of mercury

_____j. Discharges directly into the atmosphere and is capable of pulling down to 1,000 microns

_____k. Gauge pressure plus the atmospheric pressure of 14.7 p.s.i.

1. Vacuum pump oil
2. Micron
3. Evacuation
4. Noncondensables
5. High vacuum
6. Vacuum
7. Single stage pump
8. Mercury manometer
9. Low vacuum
10. Two stage pump
11. Absolute pressure

2. List three reasons for evacuating a refrigeration system.

   a.

   b.

   c.

3. Select the effects of moisture in a refrigeration system by placing an "X" in the appropriate blank.

   ______a. Floods the bowl float

   ______b. Combined with refrigerant oil and heat, it creates sludge

   ______c. Causes deterioration of metal parts inside the refrigeration system

   ______d. Dilutes the refrigerant

   ______e. Ice crystals will form at expansion point stopping refrigerant flow

   ______f. Makes sloshing noise in compressor

   ______g. Combined with halogen type refrigerants it creates hydrochloric and hydrofluoric acid

4. Select the effects of air in a refrigeration system by placing an "X" in the appropriate blank.

   ______a. Aids in the cooling of valves

   ______b. Noncondensables combined with moisture will accelerate the formation of corrosion, acid, copperplating, and sludge

   ______c. Will take up space in condenser

   ______d. Causes bubbles in sight glass

   ______e. Increases the discharge pressure

5. Describe the effects ambient temperature has on proper evacuation.

6. Distinguish between low and high vacuum pumps by placing an "L" next to the characteristics for a low vacuum pump and an "H" next to the characteristics for a high vacuum pump.

_____a. Single stage or two stage

_____b. Generally of the compressor type

_____c. Single stage

_____d. Rated at 1 to 5 c.f.m.

_____e. Rated at 1 cubic foot per minute (c.f.m.) or less

_____f. Belt or direct coupling drive

7. List six steps in the care of vacuum pumps.

8. Describe the three types of vacuum indicators.

a. Compound gauge

b. Mercury manometer

c. Electronic vacuum gauge

9. Demonstrate the ability to:

   a. Use the vacuum steam table.

   b. Evacuate a refrigeration system and use a mercury manometer.

   c. Evacuate a refrigeration system and use an electronic vacuum gauge.

   d. Triple evacuate.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

EVACUATION
UNIT II

ANSWERS TO TEST

1. a. 3
   b. 8
   c. 1
   d. 9
   e. 4
   f. 10
   g. 6
   h. 5
   i. 2
   j. 7
   k. 11
2. a. To remove noncondensables from the system
   b. To remove oil trapped refrigerant
   c. To remove moisture from the system
3. b, c, e, g
4. b, c, e
5. Description should include:
   a. Moisture is removed in a vapor state
   b. Boiling temperature decreases as the pressure decreases
   c. Increasing the ambient temperature will decrease evacuation time
6. a. H
   b. L
   c. L
   d. H
   e. L
   f. H
7. a. Check to see if the pump will pull a vacuum on itself
   b. Change oil after every extensive evacuation
   c. Keep pump clean
   d. Keep caps on the inlet and outlet ports
   e. Do not discharge refrigerant through the vacuum pump
   f. Do not operate vacuum pump with a low oil level

8. Description should include:
   a. Compound gauge
      1) Used in conjuction with other vacuum indicators
      2) Accurate to 25" Hg
      3) Should not be sole indicator
      4) Vacuum is read on the 0 to 30" part of the gauge
   b. Mercury manometer
      1) Accurate below 25" Hg
      2) Keep capped when not in use
      3) Must be kept in vertical position when using
      4) Vacuum is read directly
      5) Will indicate a leak or moisture still in the system after the pump is shut off
         a) No change in reading indicates the system is okay
         b) Reading returns to atmospheric pressure indicates a leak
         c) Slight change in reading indicates moisture still in the system
   c. Electronic vacuum gauge
      1) Accurate below 29" Hg
      2) Gives accurate readings to 50 microns
      3) Use with high vacuum pumps
      4) Durable enough for field use
9. Performance skills evaluated to the satisfaction of the instructor

PROGRESS CHART

Basic Compression Refrigeration

______________________ Date

Air Conditioning and Refrigeration

Section F

What The Trainee Should Be Able To Do

Names	Assemble a refrigeration system	Install a filter-drier with flair fittings	Install a filter-drier with sweat fittings	Install a capillary tube into a filter drier	Install a liquid indicator with flare fittings	Use a stem type service valve	Install a line tap service valve	Install an access core type service valve	Compute temperature-pressure problems	Pressure check a domestic refrigerator	Pressure check an air conditioner	Pressure check a commercial refrigerator	Determine type of refrigerant used in a central air conditioner	Use the vacuum steam table	Evacuate a refrigeration system and use a mercury manometer	Evacuate a refrigeration system and use an electronic vacuum gauge	Triple evacuate
1																	
2																	
3																	
4																	
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PROGRESS CHART

Basic Compression Refrigeration

Date ______________________

Air Conditioning and Refrigeration

Section F

What The Trainee Should Be Able To Do

Names	Assemble a refrigeration system	Install a filter-drier with flair fittings	Install a filter-drier with sweat fittings	Install a capillary tube into a filter drier	Install a liquid indicator with flare fittings	Use a stem type service valve	Install a line tap service valve	Install an access core type service valve	Compute temperature-pressure problems	Pressure check a domestic refrigerator	Pressure check an air conditioner	Pressure check a commercial refrigerator	Determine type of refrigerant used in a central air conditioner	Use the vacuum steam table	Evacuate a refrigeration system and use a mercury manometer	Evacuate a refrigeration system and use an electronic vacuum gauge	Triple evacuate
1																	
2																	
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PRESSURIZING AND LEAK TESTING
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to define terms associated with pressurizing and leak testing, list the safety rules for pressurizing a refrigeration system, and list the steps for determining if a leak exists. He should also be able to arrange the steps for pressurizing and use soap bubbles, a halide torch, and an electronic leak detector to find a refrigerant leak. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define terms associated with pressurizing and leak testing.
2. List five safety rules for pressurizing a refrigeration system.
3. List five steps for determining if a refrigerant leak exists.
4. Arrange in order the steps for pressurizing a refrigeration system.
5. Demonstrate the ability to:
    a. Leak check using soap bubbles.
    b. Leak check using a halide torch.
    c. Leak check using an electronic detector.
    d. Pressurize system with dry nitrogen and leak check.
    e. Leak check using refrigerant plus nitrogen.

PRESSURIZING AND LEAK TESTING
UNIT I

SUGGESTED ACTIVITIES

I. Instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss the procedures outlined in the job sheets.

   G. Emphasize the precautions to be taken when pressurizing with nitrogen.

   H. Give test.

II. Student:

   A. Read objective sheet.

   B. Study information sheet.

   C. Complete job sheets.

   D. Do extra projects in order to become proficient in the art of leak testing.

   E. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Pressurizing a Refrigeration System

      2. TM 2--Dry Nitrogen Cylinder and Regulator

PRESSURIZING AND LEAK TESTING
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Dry nitrogen--Oil pumped nitrogen in a pressurized cylinder, used for pressurizing refrigeration components and sweeping the system while soldering or brazing

(NOTE: Specify dry nitrogen when ordering because some nitrogen is water pumped which would contaminate the system.)

B. Regulator--Device for reducing high cylinder pressure to a low working pressure

(NOTE: Nitrogen regulators have internal pressure relief valves to prevent cylinder pressure from entering the system in case of regulator failure.)

C. Acid brush--Small, stiff bristle brush which is often used for applying flux or soap bubbles

II. Safety rules for pressurizing a refrigeration system

A. Wear safety glasses

B. Never use oxygen or acetylene to pressurize a system

(NOTE: Oxygen will explode on contact with oil. Acetylene will explode under pressure above 15 p.s.i.g.)

C. Never use dry nitrogen without a regulator

(CAUTION: Nitrogen cylinders contain pressures in excess of 2000 p.s.i.)

D. Never apply intense heat to a pressurized cylinder or system

E. Refrigeration systems must never be pressurized over 150 p.s.i.g. during a leak test

III. Determining if a leak exists

A. Check evaporator temperature

B. Check suction pressure

INFORMATION SHEET

C. Check high side pressure

(NOTE: Pressure readings alone should not be the determining factor of a refrigerant shortage.)

D. Look for oil spots

E. Look for obvious line breaks

IV. Steps for pressurizing a refrigeration system (Transparency 1)

A. Connect gauge set to system

B. Crack service valves

C. Attach gauge set center hose to nitrogen regulator

D. Turn regulator adjusting screw counterclockwise (Transparency 2)

(NOTE: Be careful not to turn the regulator adjusting screw so far that it comes out of the threaded portion of the regulator.)

E. Crack the nitrogen cylinder valve one-quarter of a turn

F. Turn regulator adjusting screw clockwise until desired pressure is obtained

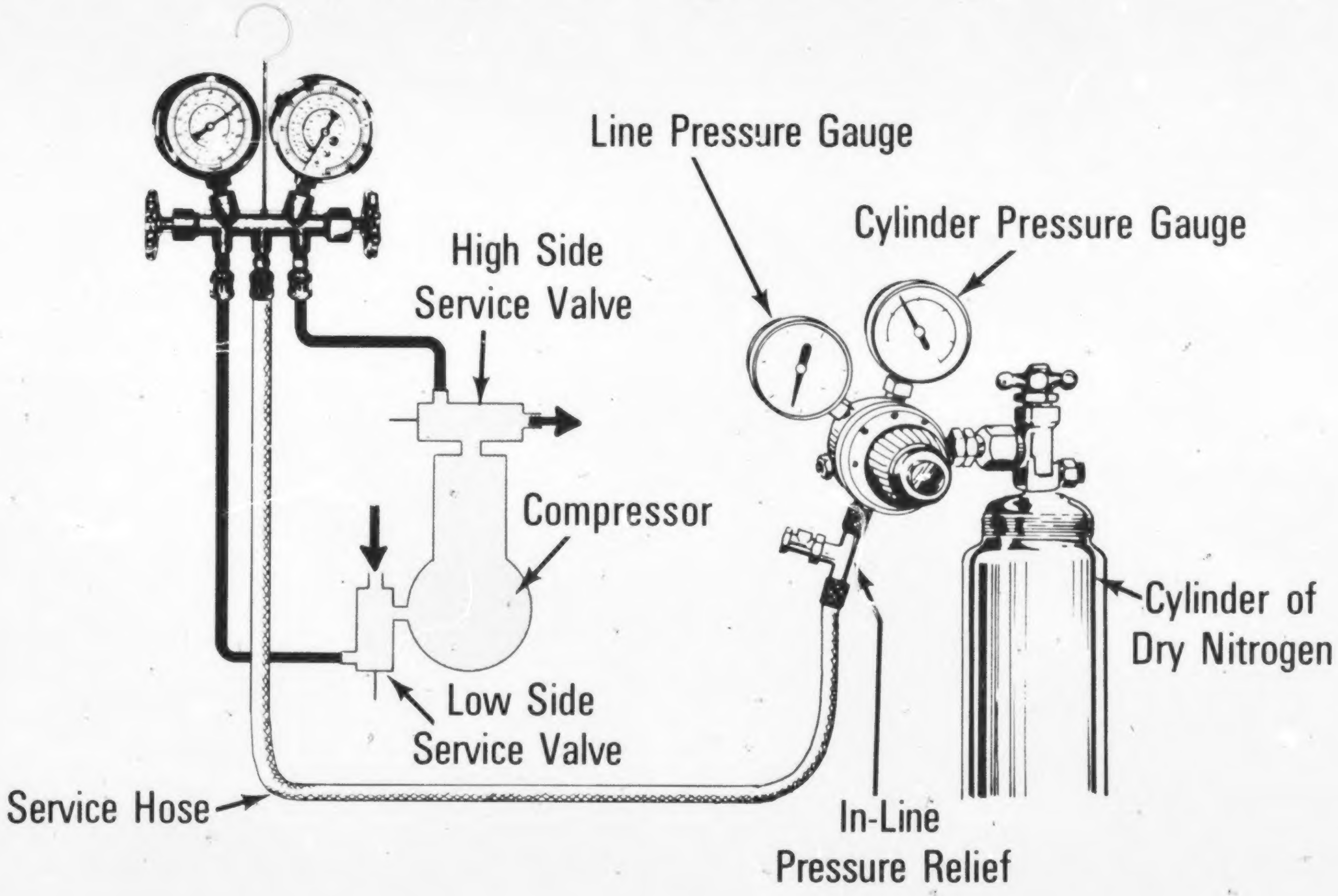
(NOTE: Generally 100 p.s.i.g. is sufficient pressure for leak testing.)

G. Open the valve on the high side of the gauge manifold

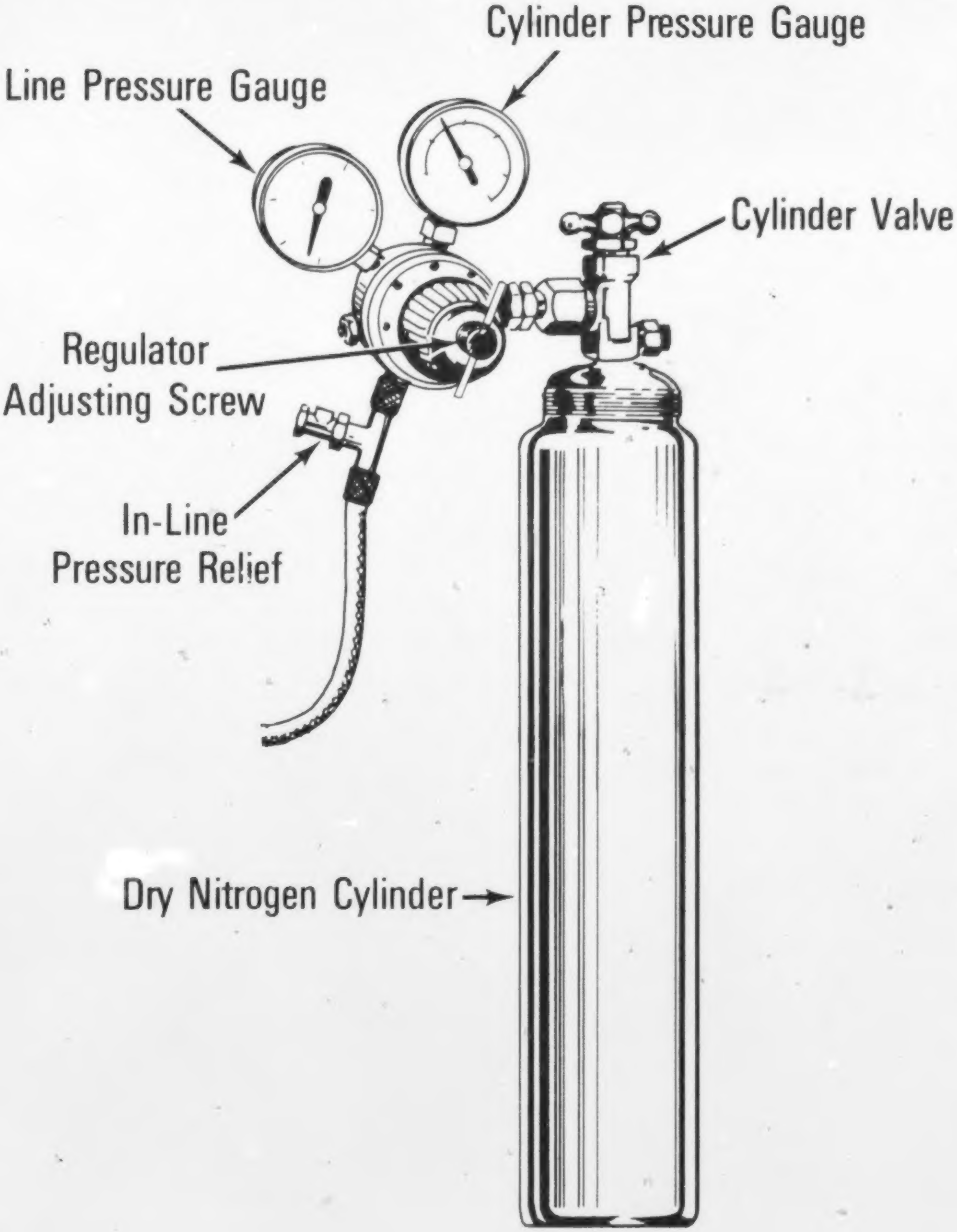
H. Allow high side and low side pressures to equalize

(NOTE: The low side gauge manifold valve remains closed during this operation. If the low side gauge pressure does not increase this could indicate a possible restriction.)

Pressurizing a Refrigeration System


Line Pressure Gauge
Cylinder Pressure Gauge
High Side Service Valve
Compressor
Cylinder of Dry Nitrogen
Low Side Service Valve
Service Hose
In-Line Pressure Relief

Dry Nitrogen Cylinder and Regulator


Cylinder Pressure Gauge
Line Pressure Gauge
Cylinder Valve
Regulator Adjusting Screw
In-Line Pressure Relief
Dry Nitrogen Cylinder

PRESSURIZING AND LEAK TESTING
UNIT I

JOB SHEET #1--LEAK CHECK USING SOAP BUBBLES

I. Tools and materials

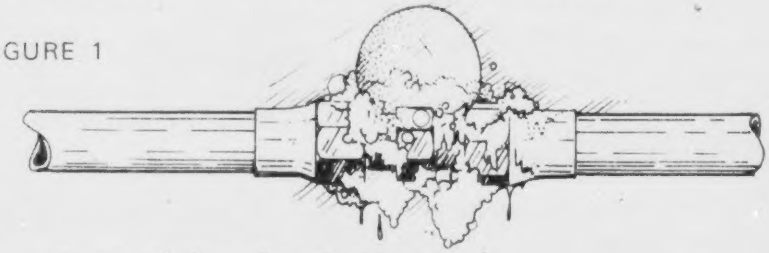
- A. Refrigeration gauge set
- B. Soap bubble solution
- C. Acid brush (clean)
- D. Refrigeration ratchet
- E. Open end wrench
- F. Refrigeration system
- G. Clean shop towel

II. Procedure

- A. Connect refrigeration gauge set to the refrigeration system
- B. Crack service valves
- C. Allow the pressures to equalize

  (NOTE: If there is not positive pressure on the entire system, do not apply the soap solution.)
- D. Locate areas of suspected leaks
- E. Apply the soap solution
- F. Look for a bubble that would indicate a leak (Figure 1)

FIGURE 1



- G. Remove soap solution after checking

  (NOTE: If the soap solution is left on the tubing it will create a film that may result in a corrosion.)
- H. Check with instructor before continuing

PRESSURIZING AND LEAK TESTING
UNIT I

JOB SHEET #2--LEAK CHECK USING A HALIDE TORCH

I. Tools and materials

   A. Refrigeration gauge set

   B. Halide torch

   C. Striker

   D. Safety glasses

   E. Refrigeration ratchet

   F. Open end wrench

   G. Refrigeration system

II. Procedure

   A. Connect refrigeration gauge set to the refrigeration system

   B. Crack service valves

   C. Allow the pressures to equalize

      (NOTE: There should be approximately 50 p.s.i.g. or more of pressure on the system for effective leak checking.)

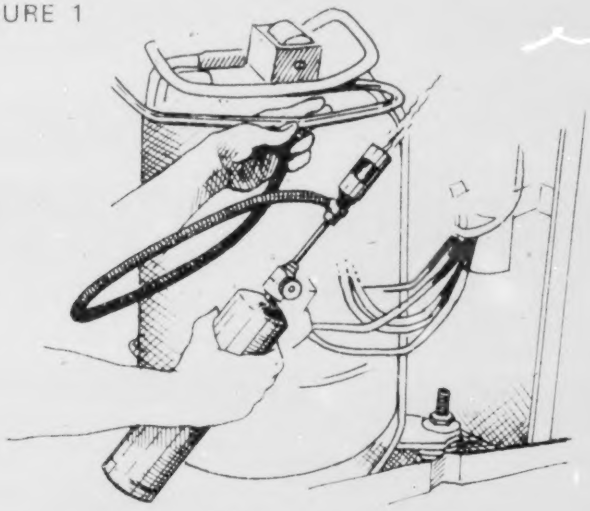
   D. Locate areas of suspected leaks

   E. Light the halide torch

JOB SHEET #2

F. Hold the sniffer hose of the torch so that the hand will trap the refrigerant (Figure 1)

FIGURE 1



G. Move sniffer hose slowly underneath the suspected leak area

(NOTE: Fluorocarbon refrigerants are heavier than air and will collect underneath the joint or suspected area.)

H. Watch the color of the torch flame for an indication of a leak

(CAUTION: Have adequate ventilation when using the halide torch due to the creation of phosgene gas.)

I. Recheck the leak with the soap solution

J. Remove the soap solution after checking

K. Check with the instructor before continuing

PRESSURIZING AND LEAK TESTING
UNIT I

JOB SHEET #3--LEAK CHECK USING AN ELECTRONIC DETECTOR

I. Tools and materials

A. Refrigeration gauge set

B. Electronic leak detector

C. Refrigeration ratchet

D. Open end wrench

E. Refrigeration system

II. Procedure

A. Connect refrigeration gauge set to the refrigeration system

B. Crack service valves

C. Allow the pressures to equalize

D. Locate areas of suspected leaks

E. Turn on electronic leak detector

F. Allow 3 to 5 minutes for detector to warm up

(NOTE: If there is a heavy concentration of refrigerant in the area, do not use the electronic leak detector as it will give false indications. Also, a heavy concentration of refrigerant will damage the sensing element.)

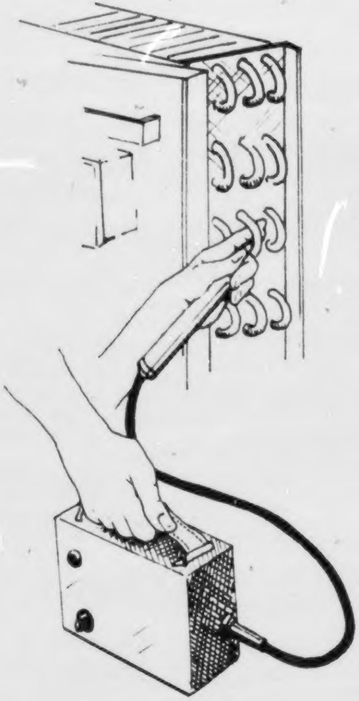
G. Adjust the leak detector

(NOTE: Have the instructor demonstrate the proper adjusting procedure for the leak detector you are using.)

JOB SHEET #3

H. Hold the probe underneath the suspected leak area (Figure 1)

FIGURE 1



I. Watch and/or listen for the detector to indicate a refrigerant leak

J. Recheck the leak with the soap solution

K. Remove the soap solution after checking

L. Check with the instructor before continuing

PRESSURIZING AND LEAK TESTING
UNIT I

JOB SHEET #4--PRESSURIZE SYSTEM WITH DRY NITROGEN AND LEAK CHECK

I. Tools and materials

A. Refrigeration gauge set

B. Dry nitrogen with regulator

C. Refrigeration ratchet

D. Open end wrench

E. Refrigeration system

F. Soap solution

II. Procedure

A. Connect refrigeration gauge set to the refrigeration system

B. Crack service valves

C. Attach gauge set center hose to nitrogen regulator

D. Turn regulator adjusting screw counterclockwise

(NOTE: Be careful not to turn the regulator adjusting screw so far that it comes out of the threaded portion of the regulator.)

E. Crack the nitrogen cylinder valve one-quarter of a turn

F. Turn regulator adjusting screw clockwise until desired pressure is obtained

(NOTE: Generally 100 p.s.i.g. is sufficient pressure for leak testing.)

G. Open the valve on the high side of the gauge manifold

H. Allow high side and low side pressures to equalize

I. Leak check the system with a soap bubble solution

(NOTE: A halide torch or electronic leak detector cannot be used as they will not react to nitrogen.)

J. Check with the instructor after locating the leak

PRESSURIZING AND LEAK TESTING
UNIT I

JOB SHEET #5 LEAK CHECK USING REFRIGERANT PLUS NITROGEN

I. Tools and materials

- A. Refrigeration gauge set
- B. Halide torch and/or electronic leak detector
- C. Refrigeration ratchet
- D. Open end wrench
- E. Safety glasses
- F. Dry nitrogen
- G. Refrigeration system
- H. Refrigerant 12 or 22

II. Procedure

- A. Connect refrigeration gauge set to the refrigeration system
- B. Crack service valves
- C. Attach refrigerant cylinder to the center hose of the gauge set
- D. Leave refrigerant cylinder in the upright position
- E. Open refrigerant cylinder valve
- F. Open the valve on the high side of the gauge manifold
- G. Allow refrigerant pressure to equalize at 50 p.s.i.g.
- H. Close high side manifold valve
- I. Close refrigerant cylinder valve
- J. Loosen refrigerant hose at cylinder valve
- K. Allow hose pressure to escape
- L. Remove hose from refrigerant cylinder
- M. Attach gauge set center hose to nitrogen regulator

JOB SHEET #5

N. Check to be sure regulator adjusting screw is not turned in

O. Crack the nitrogen cylinder valve one-quarter of a turn

P. Purge center hose

Q. Turn regulator and adjusting screw clockwise until desired pressure is obtained

(NOTE: Generally 100 p.s.i.g. is sufficient pressure for leak testing.)

R. Open the valve on the high side of the gauge manifold

S. Allow high side and low side pressures to equalize

T. Leak check the system with a halide torch and/or an electronic leak detector

U. Check with the instructor after locating the leak

PRESSURIZING AND LEAK TESTING
UNIT I

TEST

1. Define terms associated with pressurizing and leak testing.
   a. Regulator
   b. Acid brush
   c. Dry nitrogen
2. List five safety rules for pressurizing a refrigeration system.
   a.
   b.
   c.
   d.
   e.
3. List five steps for determining if a refrigerant leak exists.
   a.
   b.
   c.
   d.
   e.

4. Arrange in order the following steps by placing the correct sequence number in the appropriate blank.

______a. Crack the nitrogen cylinder valve one-quarter of a turn

______b. Open the valve on the high side of the gauge manifold

______c. Connect gauge set to system

______d. Turn regulator adjusting screw counterclockwise

______e. Turn regulator adjusting screw clockwise until desired pressure is obtained

______f. Attach gauge set center hose to nitrogen regulator

______g. Allow high side and low side pressures to equalize

______h. Crack service valves

5. Demonstrate the ability to:

a. Leak check using soap bubbles.

b. Leak check using a halide torch.

c. Leak check using an electronic detector.

d. Pressurize system with dry nitrogen and leak check.

e. Leak check using refrigerant plus nitrogen.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

PRESSURIZING AND LEAK TESTING
UNIT I

ANSWERS TO TEST

1. a. Regulator--Device for reducing high cylinder pressure to a low working pressure

   b. Acid brush--Small, stiff bristle brush which is often used for applying flux or soap bubbles

   c. Dry nitrogen--Oil pumped nitrogen in a pressurized cylinder, used for pressurizing refrigeration components and sweeping the system while soldering and brazing

2. a. Wear safety glasses

   b. Never use oxygen or acetylene to pressurize a system

   c. Never use dry nitrogen without a regulator

   d. Never apply intense heat to a pressurized cylinder or system

   e. Refrigeration systems must never be pressurized over 150 p.s.i.g. during a leak test

3. a. Check evaporator temperature

   b. Check suction pressure

   c. Check high side pressure

   d. Look for oil spots

   e. Look for obvious line breaks

4. a. 5

   b. 7

   c. 1

   d. 4

   e. 6

   f. 3

   g. 8

   h. 2

5. Performance skills evaluated to the satisfaction of the instructor

CHARGING
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to match terms associated with charging to the correct definitions, list safety precautions, and list advantages and disadvantages of low side vapor charging. He should also be able to select the advantages and disadvantages of high side liquid charging. This knowledge will be evidenced through demonstration and by scoring eighty-five percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with charging to the correct definitions or descriptions.
2. List safety precautions for refrigerant handling.
3. List two advantages and two disadvantages of low side vapor charging.
4. Select the advantages and disadvantages of high side liquid charging.
5. Demonstrate the ability to:
    a. Vapor charge.
    b. Liquid charge.

CHARGING
UNIT II

SUGGESTED ACTIVITIES

I. Instructor:

- A. Provide student with objective sheet.
- B. Provide student with information and job sheets.
- C. Make transparencies.
- D. Discuss unit and specific objectives.
- E. Discuss information sheet.
- F. Demonstrate and discuss the procedures outlined in the job sheets.
- G. Give test.

II. Student:

- A. Read objective sheet.
- B. Study information sheet.
- C. Complete job sheets.
- D. Take test.

INSTRUCTIONAL MATERIALS

I. Included in this unit:

- A. Objective sheet
- B. Information sheet
- C. Transparency masters
  - 1. TM 1--Low Side Vapor Charging
  - 2. TM 2--High Side Liquid Charging at the Discharge Service Valve
  - 3. TM 3--High Side Liquid Charging at the King Valve

D. Job sheets

1. Job Sheet #1--Vapor Charge

2. Job Sheet #2--Liquid Charge

E. Test

F. Answers to test

II. Reference--Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. *Modern Refrigeration and Air Conditioning.* Homewood, Illinois: Goodheart-Willcox and Co., 1975.

CHARGING
UNIT II

INFORMATION SHEET

I. Terms and definitions or descriptions

A. Upright--Refrigerant cylinder is standing up with valve on top and vapor is dispensed from the cylinder

B. Inverted--Refrigerant cylinder is turned upside down with valve on bottom and liquid is dispensed from the cylinder

C. Hose purging--Releasing some refrigerant to the air to remove contaminants from the gauge hoses

D. Stabilized--Condition that shows a constant gauge reading

E. Static pressure--Pressure readings of a system when it is not running

II. Safety precautions for refrigerant handling

A. Do not drop cylinders

B. Do not refill disposable refrigerant cylinders

C. Do not heat cylinders with a torch

D. Secure cylinders in a moving vehicle

E. Do not spray refrigerant on skin

F. Do not inhale refrigerant

G. Do not spray refrigerant into open flame

H. Do not mix refrigerants

I. Replace cylinder cap when not in use to protect valve

J. Do not lift or carry cylinder by valve

K. Secure large cylinders to wall or bench

L. Have adequate ventilation

M. Remove valve or puncture cylinder when discarding disposable refrigerant cylinders

INFORMATION SHEET

III. Low side vapor charging (Transparency 1)

  A. Advantages

    1. Easiest method of adding refrigerant to a charged system

    2. Liquid refrigerant cannot enter suction side of the compressor

  B. Disadvantages

    1. Slow process for adding large quantities of refrigerant

       (NOTE: When large quantities of refrigerant are drawn out of a cylinder, the pressure in the cylinder will drop below the system pressure and the transfer of refrigerant will stop.)

    2. High drum pressure could wash out compressor oil

IV. High side liquid charging (Transparencies 2 and 3)

  A. Advantage--Fast

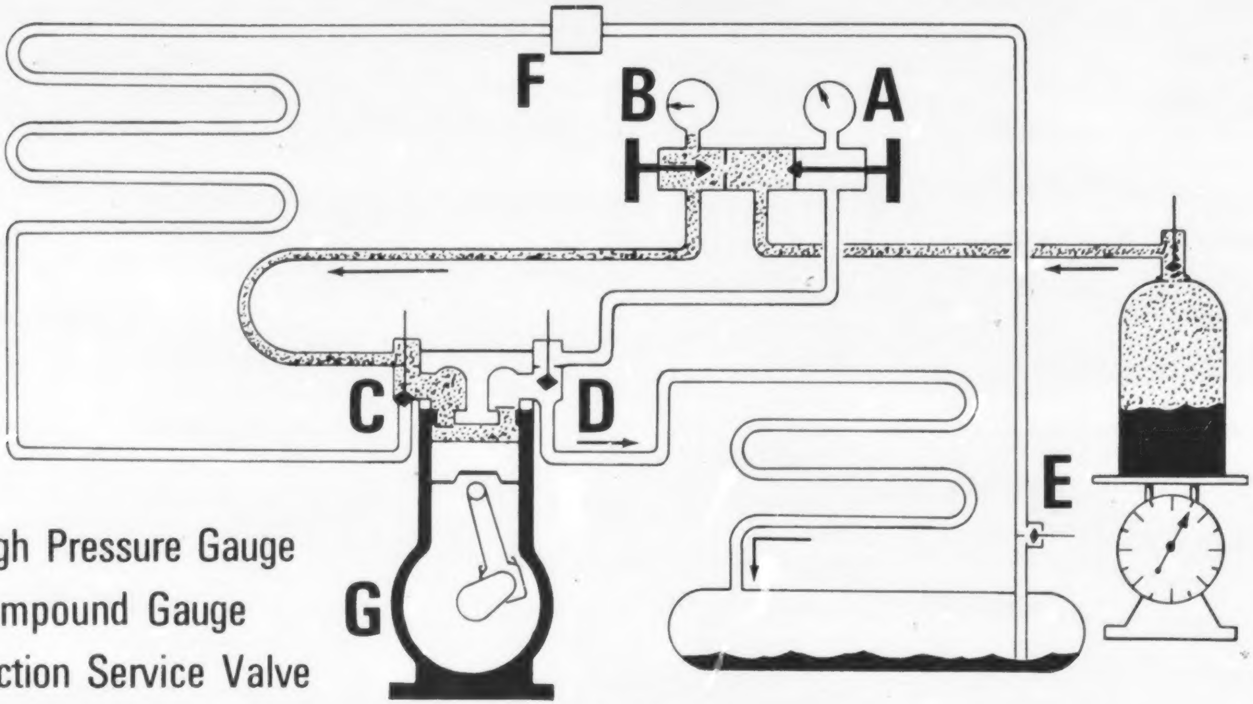
  B. Disadvantages

    1. System may have to be turned off

       (NOTE: If the system is equipped with a liquid charging valve on the receiver, the system may not need to be turned off.)

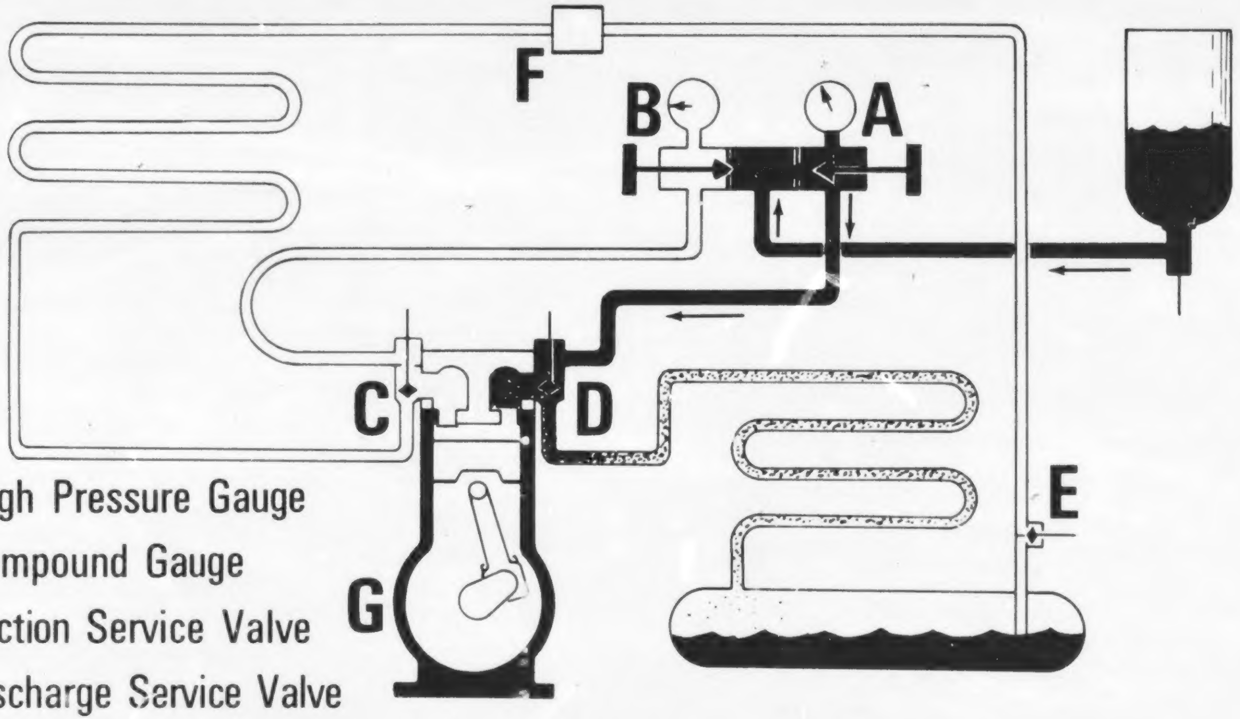
    2. Easy to overcharge

Low Side Vapor Charging



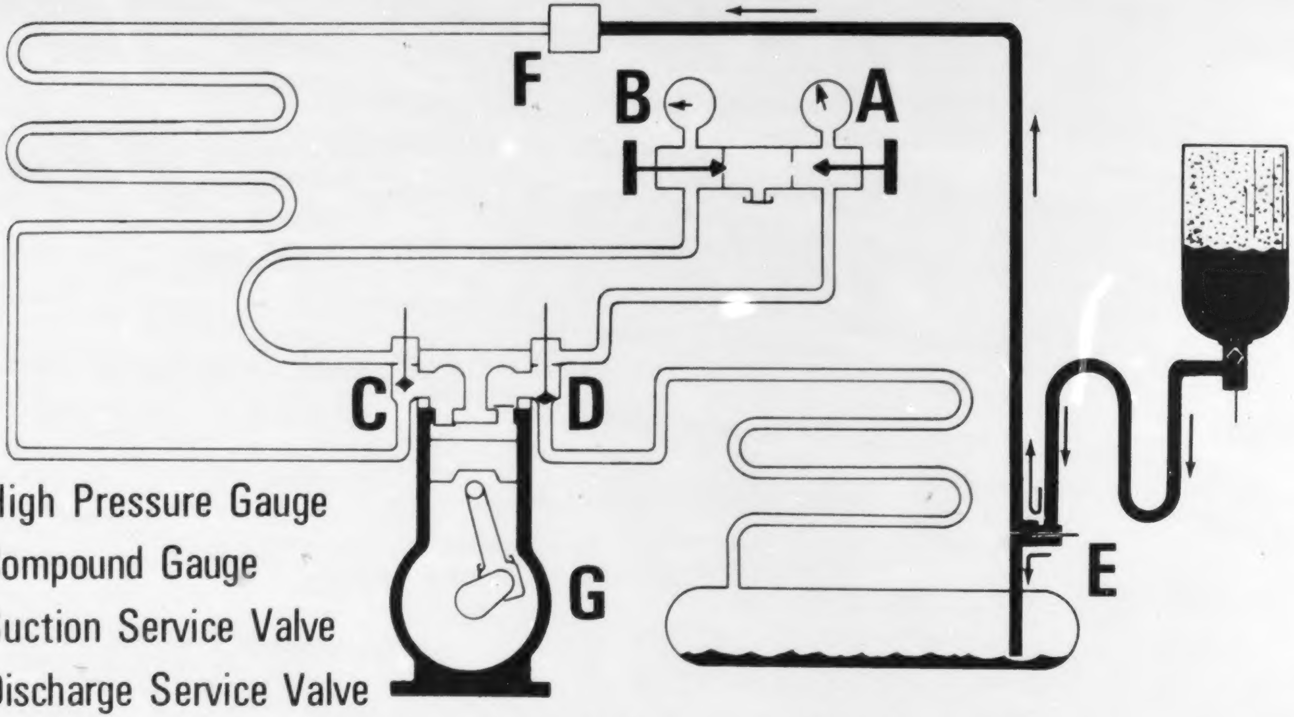
- A. High Pressure Gauge
- B. Compound Gauge
- C. Suction Service Valve
- D. Discharge Service Valve
- E. King Valve
- F. Metering Device
- G. Compressor

High Side Liquid Charging at the Discharge Service Valve



A. High Pressure Gauge
B. Compound Gauge
C. Suction Service Valve
D. Discharge Service Valve
E. King Valve
F. Metering Device
G. Compressor

High Side Liquid Charging at the King Valve



A. High Pressure Gauge
B. Compound Gauge
C. Suction Service Valve
D. Discharge Service Valve
E. King Valve
F. Metering Device
G. Compressor

CHARGING
UNIT II

JOB SHEET #1--VAPOR CHARGE

I. Tools and materials

   A. Refrigeration gauge set

   B. Refrigeration ratchet

   C. Open end wrenches

   D. Safety glasses

   E. Pressure-temperature charts

   F. Refrigerant scales

   G. Refrigeration system with service valves

   H. Refrigerant

   I. Shop towel

II. Procedure

   A. Connect refrigeration gauge set to system

   B. Attach center hose to refrigerant cylinder

   C. Set cylinder in upright position on scales

   D. Open cylinder valve

   E. Open refrigeration gauge set valves

   F. Purge refrigerant hoses at service valve gauge ports

   (CAUTION: When purging refrigerant wear safety glasses and place a shop towel around the hose fitting to prevent the refrigerant from spraying on your skin.)

   G. Close refrigeration gauge set valves

   H. Crack service valves

   I. Record weight of refrigerant cylinder

   J. Open high side refrigeration gauge set valve

JOB SHEET #1

K. Allow vapor to enter the system until the pressure equalizes

L. Close high side refrigeration gauge set valve

M. Start system

N. Allow system to run for the pressures to stabilize

(NOTE: If the system is equipped with a low pressure safety switch, it may have to be jumpered electrically during the charging process. Check with instructor before jumpering any switches.)

O. Crack low side refrigeration gauge set valve allowing refrigerant to enter the system

P. Allow gauge pressure reading to increase 20 to 30 p.s.i.g. above system pressure

Q. Use the pressure-temperature chart to determine approximate pressure

R. After these pressures have been reached, stop charging

S. Allow system to run for pressures to stabilize

T. Recheck pressures

U. Add more refrigerant if necessary

V. Have instructor check

W. Back seat service valves

X. Close refrigerant cylinder valve

Y. Record cylinder weight

(NOTE: Cylinder weight is recorded to determine the amount of refrigerant that has been dispensed and to determine what to charge the customer.)

Z. Figure the amount of refrigerant used

AA. Purge gauge set hoses

BB. Remove gauge set and plug hoses

CC. Replace and tighten all valve caps

DD. Clean up and put away tools

CHARGING
UNIT II

JOB SHEET #2--LIQUID CHARGE

I. Tools and materials

   A. Refrigeration gauge set

   B. Refrigeration ratchet

   C. Open end wrenches

   D. Safety glasses

   E. Shop towel

   F. Refrigerant scales

   G. Refrigeration system with service valves

   H. Refrigerant

II. Procedure

   A. Connect refrigeration gauge set to system

   B. Attach center hose to refrigerant cylinder

   C. Set cylinder in upright position on scales

   D. Open cylinder valve

   E. Open refrigeration gauge set valves

   F. Purge refrigerant hoses at service valve gauge ports

   (CAUTION: When purging refrigerant wear safety glasses and use a cloth around the hose fitting to prevent the refrigerant from spraying on your skin.)

   G. Close refrigeration gauge set valves

   H. Crack service valves

   I. Record weight of refrigerant cylinder

   J. Invert refrigerant cylinder

   K. Open high side refrigeration gauge set valve

JOB SHEET #2

L. Allow liquid refrigerant to enter the system

M. Watch the refrigerant scales

N: Close gauge set valve when desired amount of refrigerant has entered the system

O. Start system

P. Run system for the pressures to stabilize

Q. Check for the following indications that additional refrigerant is needed:

  1. Bubbles in liquid indicator (sight glass)

  2. Low pressure readings

  3. Frost line on evaporator

R. Additional refrigerant will have to be added in the vapor state

(NOTE: Vapor charging is covered in Job Sheet #1.)

S. Record cylinder weight

T. Have instructor check

U. Figure the amount of refrigerant used

V. Back seat service valves

W. Purge hoses of refrigerant by opening the manifold valves and allowing the refrigerant to discharge through center hose

(NOTE: On systems using access core type valves the hoses cannot be purged of refrigerant prior to removing them.)

X. Remove gauge set and plug hoses

Y. Replace and tighten all valve caps

Z. Clean up and put away tools

CHARGING
UNIT II

TEST

1. Match the terms on the right to the correct definitions or descriptions.

   _____a. Refrigerant cylinder is turned upside down with valve on bottom and liquid is dispensed from the cylinder

   _____b. Condition that shows a constant gauge reading

   _____c. Releasing some refrigerant to the air to remove contaminants from the gauge hoses

   _____d. Pressure readings of a system when it is not running

   _____e. Refrigerant cylinder is standing up with valve on top and vapor is dispensed from the cylinder

   1. Hose purging
   2. Static pressure
   3. Upright
   4. Stabilized
   5. Inverted

2. List eight safety precautions for refrigerant handling.

   a.

   b.

   c.

   d.

   e.

   f.

   g.

   h.

3. List two advantages and two disadvantages of low side vapor charging.

   a. Advantages

      1)

      2)

b. Disadvantages

1)

2)

4. Select the advantages and disadvantages of high side liquid charging by placing an "X" by the advantages and an "O" by the disadvantages.

______a. Fast

______b. Slow

______c. System must be running

______d. Easy to overcharge

______e. Impossible to overcharge

______f. System may have to be turned off

5. Demonstrate the ability to:

a. Vapor charge.

b. Liquid charge.

(NOTE: If these activities have not been accomplished prior to the test, ask your instructor when they should be completed.)

CHARGING
UNIT II

ANSWERS TO TEST

1. a. 5

   b. 4

   c. 1

   d. 2

   e. 3

2. Any eight of the following:

   a. Do not drop cylinders

   b. Do not refill disposable refrigerant cylinders

   c. Do not heat cylinders with a torch

   d. Secure cylinders in a moving vehicle

   e. Do not spray refrigerant on skin

   f. Do not inhale refrigerant

   g. Do not spray refrigerant into open flame

   h. Do not mix refrigerants

   i. Replace cylinder cap when not in use to protect valve

   j. Do not lift or carry cylinder by valve

   k. Secure large cylinders to wall or bench

   l. Have adequate ventilation

   m. Remove valve or puncture cylinder when discarding disposable refrigerant cylinders

3. a. Advantages

      1) Easiest method of adding refrigerant to a charged system

      2) Liquid refrigerant cannot enter suction side of the compressor

b. Disadvantages
    1) Slow process for adding large quantities of refrigerant
    2) High drum pressure could wash out compressor oil

4. a. X
   d. O
   f. O

5. Performance skills evaluated to the satisfaction of the instructor

PROGRESS CHART

Refrigerant System Servicing

Date ____________________

Air Conditioning and Refrigeration

Section G

What The Trainee Should Be Able To Do

Names	Leak check using soap bubbles	Leak check using a halide torch	Leak check using an electronic detector	Pressurize system with dry nitrogen and leak check	Leak check using refrigerant plus nitrogen	Vapor charge	Liquid charge
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							

PROGRESS CHART

Refrigerant System Servicing

____
Date

Air Conditioning and Refrigeration

Section G

What The Trainee Should Be Able To Do

Names	Leak check using soap bubbles	Leak check using a halide torch	Leak check using an electronic detector	Pressurize system with dry nitrogen and leak check	Leak check using refrigerant plus nitrogen	Vapor charge	Liquid charge																																						
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